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ASTRONOMICAL TELESCOPES AT THE MANCHESTER EXHIBITION.

AMONG the numerous interesting exhibits to be found in the important section devoted to Irish industries at the late Manchester exhibition, one of the most interesting was the collection of astronomical telescopes and their adjuncts to be found at the stand of Sir Howard Grubb, of Dublin, the maker of the great equatorial refractor at the Vienna Observatory. In his collection at Manchester, the largest instrument exhibited by Sir Howard was the twin equatorial telescope, of which we give a perspective view and engravings of various details.

This telescope is of a pattern which has been expressly designed for photographic work, combined with general observing purposes, and of which examples have also been constructed for the use of Dr. Huggins, of London, and Mr. Isaac Roberts, of Liverpool. It consists of a refracting telescope of 8 in. aperture carried by the same mounting as a reflecting telescope with a silvered glass mirror 17 in. in diameter, the two telescopes being mounted on opposite ends of the declination axis, but having independent movements in declination, as we shall explain presently. In right ascension the two telescopes of course move together.

The 8 in. refractor has a focal length of about 10 ft., and may be regarded as practically identical in its details with Sir Howard Grubb's standard instruments of this size, except that an incandescent electric light is used in place of the ordinary lamps for illuminating the declination circle, the field of the micrometer, etc. The declination circle is read from the eye end of the telescope, from which position the slow motions and the clamps can also be operated. The reflecting telescope is arranged for photographic work only, no provision being made for using it for direct vision. The eyepiece seen at the mirror end is for use in focusing the photographic plates, which are placed in a suitable carrier mounted in the mouth of the telescope at the focus of the mirror. The image is thus received direct on the sensitive plates from the mirror without any intermediate reflection. An aperture in the center of the mirror enables a view for focusing to be obtained through the eyepiece named above. As in the case of the refracting portion of the instrument, the declination circle is illuminated by an incandescent electric light and is read from the eye end of the telescope, from which end the clamps, etc., can also be operated as in the case of the refractor.

The periods of exposure of sensitive plates when taking astronomical photographs vary from a very minute fraction of a second, when taking views of the sun, to periods of two or even three hours when obtaining photographs of the fainter stars and nebulæ, and it is manifest that the accurate direction of the telescope, so as to prevent the shifting of the image on the sensitive plate, is a matter involving grave difficulties. Of course, the chief apparent motion of a star is that due to the rotation of the earth, and if this was the only movement which had to be dealt with, all that would have to be sought would be the utmost possible regularity of driving of the clock by which motion is given to the telescope in a direction opposed to that of the earth's rotation. This chief apparent movement, however, is disturbed by the effect of refraction, which causes a star to appear higher above the horizon than it really is, and the influence of which becomes greater the lower the altitude at which the star is situated. As the apparent movement of the stars due to the earth's rotation is parallel to the equator, and consequently at an angle to the horizon (except in the case of polar stations, at present unknown), it follows, first, that the effect of refraction on this movement is constantly varying, and secondly, that except when the star is absolutely on the meridian, this effect alters the apparent position of the object in right ascension as well as in declination. If the star which is being photographed be either wholly east or wholly west of the meridian during the period of exposure, the disturbing influence of refraction as regards the position in right ascension can be very closely compensated for by giving the clock a slight plus or a slight minus rate; but up to the present no attempt has been made to compensate automatically for the disturbance of the apparent position in declination, and it appears to be tacitly admitted by astronomical photographers that this correction at least must be done by hand. To enable this operation to be successfully carried out with the instrument under notice, the reflecting telescope is, as will be seen from our perspective view, provided with a powerful finder of 5 in. aperture, this finder being fitted with micrometer wires for fixing the position in the field of the star used as a guide. During the exposure of the photographic plate a constant observation of the star is maintained through the finder, and any indication of the star shifting from its proper position on the field is at once corrected by hand, slow movements in declination and right ascension of very great delicacy being provided for this purpose.

The remarks which we have made above will show the great importance of extremely regular driving in the case of such an instrument as that with which we are dealing, and we have now to describe Sir Howard Grubb's arrangements for securing this end. As will be seen from the perspective view, the general design of the mounting is the same as that of Sir Howard's standard equatorials to which reference has already been made, the column inclosing the polar axis springing from a casting of triangular shape in side elevation, within which the clockwork is inclosed. The upper end of the polar axis column is further supported by a vertical casting as shown, the whole forming a rigid arrangement. At the upper end the major part of the transverse load on the polar axis is received upon friction pulleys, which are kept up to their work by levers with adjustable counterweights, the polar axis at this point only exerting on its fixed bearing such pressure as is required to insure steady guiding. At the lower end of the polar axis the arrangement is that shown by the detail view, Fig. 5, which explains the arrangement of clamp for connecting the polar axis with the toothed sector on which the clock operates. This sector is seen in the perspective view, its periphery being geared into by a worm driven by the clock motion.

The clock motion itself may be considered as consisting of two distinct parts: namely, first, a carefully designed equatorial clock provided with a rotary governor, this clock performing the actual work of driving the telescope; and second, the control clock, which, as it were, supervises the performance of the driving clock, and automatically corrects any errors that may arise. This control clock is a most ingenious contrivance, to the perfecting of which Sir Howard Grubb has devoted much time and mechanical skill, and we are glad to say that he has attained results of a most satisfactory kind. The apparatus may at first sight appear a little complicated, but the detail views, Figs. 2, 3, and 4, will, we trust, render its mode of action clear.

The arrangement, then, consists, first, of a remontoire train driving a good mercurial or other compensated pendulum—the driving of this train being, of course, entirely independent of the equatorial clock giving motion to the telescope; secondly, of a detector apparatus which detects any difference between the rate of this standard pendulum and the equatorial clock; and third, of a correcting apparatus which corrects automatically any errors discovered by the detector. This corrector itself consists of two parts—an "accelerator" and a "retarder"—and these we will first proceed to describe.

In Fig. 3, S, S', S'' is one of the shafts between the driving train of the equatorial clock and the worm which drives the right ascension sector, this shaft being cut into three parts denoted by the letters just named. At one end, the portion, S, of the shaft carries a wheel, 1, immediately adjoining which is the wheel, 2, mounted on the portion S' of the shaft. At the other end of this last named section of the shaft is fixed a third wheel, 3, which is almost in contact with the wheel, 4, fixed on the end of the shaft, S''. The shafts, S and S'', also have mounted freely on them the brass disks, *d d'*, which adjoin the two pairs of wheels referred to above. Each of these brass disks is furnished with a stud on which a small pinion is

FIG. 1

TWIN EQUATORIAL TELESCOPE, FOR USE IN PHOTOGRAPHY—MANCHESTER EXHIBITION.

mounted, the pinion, p, belonging to disk, d, gearing across the pair of wheels, 1—2; while the pinion, p', belonging to disk, d', gears across the pair of wheels, 3—4.

Under normal conditions, if no error exists in the equatorial clock rate, the arrangement of wheels and pinions just described revolves as one piece, the three sections, S, S', S", of the shaft rotating at the same speed. But it is possible—by an arrangement which we shall explain presently—to stop the rotation of either of the disks, d d', and as soon as this occurs the pinion of the stopped disk has to act as a transmitter of motion from one of the wheels into which it gears to the other. If the two wheels of each pair had the same number of teeth, the speed of both wheels would still remain the same, but in reality the number of teeth in the two wheels of each pair is different, and hence the stopping of one of the disks, d or d', causes a variation in the rate for accelerating or retarding the driving motion imparted to the telescope by the equatorial clock. We have now to describe how this apparatus is, when necessary, automatically brought into action by the "detector."

In Figs. 2 and 3, W is a scape wheel mounted on the sixty-second spindle of the controlling clock, and driven from that spindle through a spiral spring, x x, so that no error in the equatorial clock can affect its rate or that of the standard pendulum. On the same spindle there is also mounted behind the scape wheel an ebonite disk, E E, Fig. 2, this disk, which is driven by the equatorial clock, carrying two insulated rings, b b', which are respectively connected metallically with two platinum plates, β β', inserted in the face of the disk. Between the scape wheel and the ebonite disk there is also mounted loose on the spindle a lever, A A, which carries at one of its ends a platinum bridge, B, the scape wheel and disk make a whole revolution in the same time, the pin carried by the scape wheel will be constantly oscillating between the pins of the fork at one end of the lever, A, this lever being driven by friction from the ebonite disk. The pins just named are adjusted so as to allow of this oscillation taking place without interference so long as the rates of the equatorial and control clocks remain uniform, but if the equatorial clock either loses or gains with respect to the standard, the pin on the scape wheel comes into contact with one of the fork pins of the lever, A, and shifts that lever on the spindle, bringing the bridge, B, into contact with one of the platinum plates, β or β', and transmitting a current which brings into action the accelerator or retarder as may be required. The period during which the accelerator or retarder remains in action will depend upon the amount of the

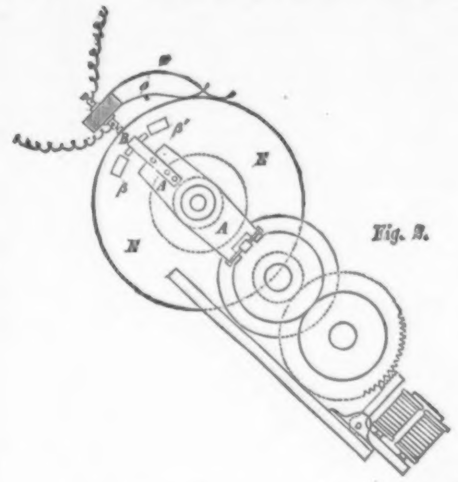


Fig. 2.

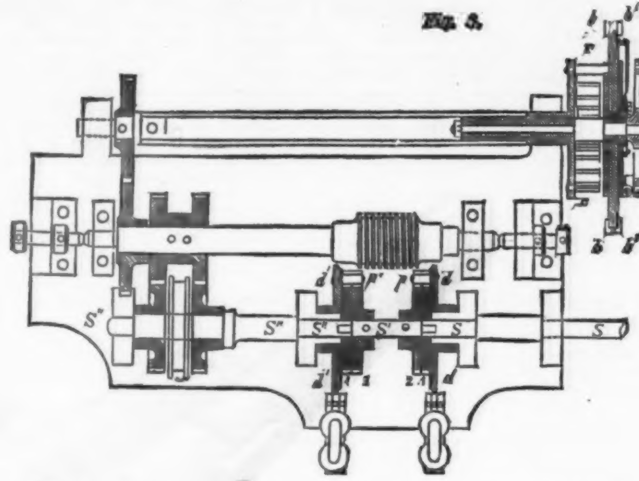


Fig. 3.

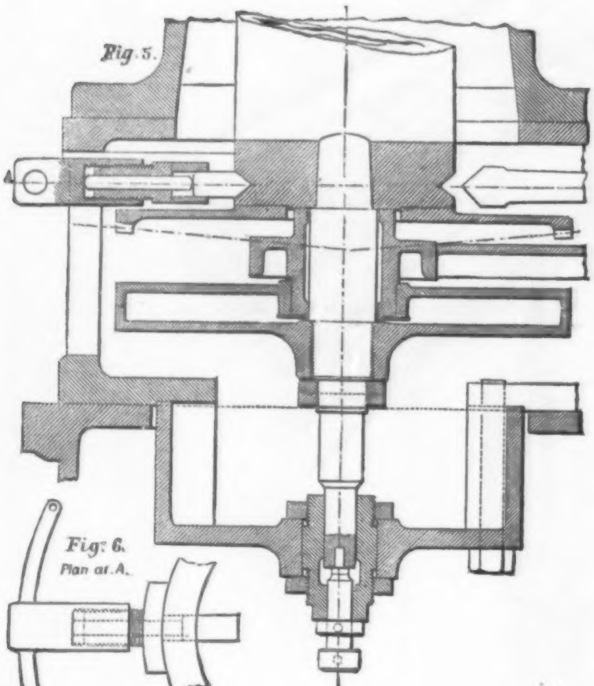


Fig. 5.

Fig. 6. Plan at A.

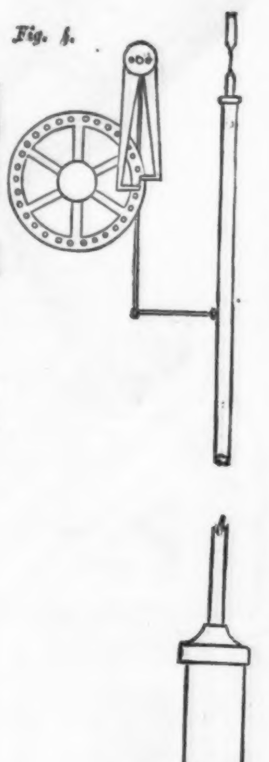


Fig. 4.

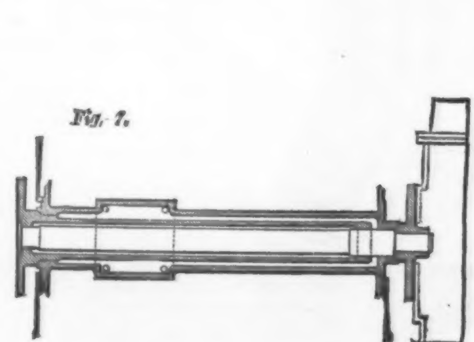


Fig. 7.

TWIN EQUATORIAL TELESCOPE—MANCHESTER EXHIBITION.

of rotation of the two adjoining wheels relatively to each other. For instance, in the case of the first pair of wheels, let wheel 1 have 30 and wheel 2 have 29 teeth, and suppose that the shaft, S, is rotating once every 60 seconds. Thus if the disk, d, be stopped, the wheel 2 will be made to revolve in $\frac{29}{30}$ of the time occupied by wheel 1, or in other words, the rate of the section, S', of the shaft will be accelerated to one revolution in 58 seconds. In the same way by reversing the positions of the wheels in the other pair, 3—4, the stoppage of the disk, d', can be made to effect a retardation of the portion, S, of the shaft relatively to S'. The edges of the disks, d and d', are cut into very fine teeth, and the stoppage of the disks when desired is effected by causing a comb attached to the armature of an electro-magnet to engage with these teeth, the arrangement being shown by Fig. 3. The whole apparatus just described constitutes a very convenient arrangement which is of such length as to fit between the platinum plates, β β', and which in its mid-position bears against a piece of rock crystal let into the ebonite disk between the two plates just named. At the other end the lever, A A, is formed into a fork, between the arms of which projects a pin carried by the scape wheel. The arms of the fork are provided with set screws by means of which the amount of play allowed to this pin in the fork can be adjusted.

The insulated rings, b b', are electrically connected with the accelerator and retarder already described by means of fine platinum wires, o o', wiping against them, and the action of the whole arrangement is as follows: The scape wheel, W, being driven by the control clock has an intermittent movement corresponding to the beats of the pendulum, while the ebonite disk, E E, being driven by the equatorial clock, has a constant movement, so that even if error to be corrected and the proportions of the teeth of the pairs of wheels, 1—2 and 3—4. With the proportions described above, the correction introduced is one-thirtieth of the rate, so that to correct an error of $\frac{1}{5}$ second, the accelerator or retarder, as the case may be, would have to remain in operation $\frac{30}{5} = 6$ seconds. As soon as the correction has been made, the lever, A, will resume its normal position, and the bridge, B, coming then between the two platinum plates, β β', a current will cease to be transmitted, and the accelerator or retarder be thrown out of action.

It is to be noted that the apparatus above described not only corrects any temporary disturbance of the equatorial clock rate, but cancels errors which have already occurred. This is most important for photographic work, as it insures the star disks being maintained in a constant position on the sensitive plate. In practice the apparatus works admirably, and maintains the equatorial clock right within errors of from $\frac{1}{5}$ to $\frac{1}{10}$ second.

Fig. 7 is a detail showing the arrangement of the declination axes of the telescopes we have been describing, and from this it will be seen that the reflector has a tubular declination axis, through which the declination axis of the refractor passes. The two telescopes are thus capable, as we have said, of independent movements in declination.

The twin equatorial we illustrate was shown at Manchester mounted with an observatory 15 feet in diameter, with dome complete, this observatory having a framing of wrought iron gas pipes arranged so that it could be covered with either canvas (for temporary purposes) or wood. The details of construction were well worked out, and the dome moved with great freedom. Adjoining the observatory was a transit room, the roof shutter of which was arranged in a novel way, which we may possibly illustrate at some future time, and which is especially simple and convenient.—*Engineering.*

THE AGE OF THE STARS.*

I.

GENTLEMEN: The great Herschel, who had included the entire heavens in his observations, and whose opinions were almost regarded as the expression of science itself, believed the sun to be inhabited. Arago, who succeeded him as an authority in physical astronomy, believed it to be habitable. This opinion of two so great men, the latter of whom almost touched on our own epoch, shows us what an advance science has made in a quarter of a century.

To-day, there is not an astronomer who would admit, even for a single instant, the possibility of the development of life on our great central luminary.

In fact, we have more correct and healthier ideas as to the role of the various members of the solar system. We know that the function of the star that is at the center of our planetary world is in nowise to serve directly in the manifestations of life (which would be a reversal of roles and an insurmountable obstacle to the accomplishment of its functions), but that, on the contrary, its structure has been admirably combined for making it the great reservoir of those forces that are to animate and preserve the entire system, and that, through its wonderful organization, it can not only spread over the worlds that it enchains around it, by its mass, those effluvia whose abundance confounds the imagination, but can even regenerate their source continuously, so that the future of these worlds, whose furnace, regulator, and life it is, is secured through immense chronological periods.

And yet it would be wrong to think that these new ideas as to the role and constitution of the sun are the fruit of direct observation. No, gentlemen; it is not through an examination of the surface of this star that we have acquired them. At the distance that we are from the sun, we could not, with our present most powerful instruments, perceive organized beings, even though they were of gigantic stature. Through the

* Lecture by Prof. Janssen at the annual meeting of the five academies.

most recent progress in solar photography, we now succeed in separating granulations of the photosphere that have an arc of only a tenth or fifteenth of a second, and this angle, so small, corresponds again to objects nearly thirty miles in diameter. How, then, have we obtained our great knowledge of the solar system?

Gentlemen, this is the place to recall a principle which is evolved from the history of the sciences, and the application of which forms the very subject that is to occupy us. It is that every great discovery comprises consequences of which it is impossible at first to measure the entire extent and range, and which always go beyond the horizon of its immediate object; it is, especially, that when several discoveries of this order are made in the various branches of the same science, or in allied sciences, they lead later on, through judicious approaches, to unexpected information of a philosophical order which is generally higher than that resulting from each discovery taken isolatedly; finally, it is that, in the system of human understanding, everything is closely connected, and we cannot introduce a new truth into it without its leading to unforeseen consequences through its alliance with all the others.

To-day astronomy offers us a remarkable example of this truth.

The great discoveries made in celestial physics in recent times, along with the knowledge that the invention of the telescope has introduced into the science, permit us now to rise to a truth of superior order, and to introduce into the universe that idea of age and evolution which up to the present has been exclusively reserved for a class of terrestrial phenomena. It is to the showing of exactly what these words "age" and "evolution," as applied to the stars, signify, and of how we have been led to introduce them into the science, that I shall devote this short lecture.

The word "age" supposes an existence that has a beginning, a development, and an end. Age implies a cycle of phenomena amenable to time. That which is eternal has no age.

The age of the stars, then, signifies that these planets are submitted to the laws of an evolution like that which the organized beings of our globe exhibit to us. So those stars whose light seems to be extra-terrestrial and of a wholly celestial nature, those stars whose fixedness has been so often taken as the symbol of immutability itself, those stars that our education and traditions have accustomed us to regard as the eternal luminaries of the heavens, are submitted, then, like our terrestrial existences, to the laws of birth and death; they, too, are amenable to time, and experience the vicissitudes that every life bears in itself.

The stars are suns analogous to our own, and they are submitted to the laws of an evolution whence result for them a beginning, a period of activity, a decline, and an end.

This doctrine of the evolution of the stars is not yet complete, and not elaborated in all its parts, but it is now obtruding itself, and it should be introduced into science, of which it will represent one of the most important progresses and one of the most splendid conquests.

We shall now briefly explain how the idea of the evolution of the stars results from the discoveries made in astronomy since the Renaissance, and how the last conquests of spectrum analysis have allowed us to penetrate the constitution of a large number of these stars distributed throughout the immensity of the heavens, and to classify them with probable accuracy according to their relative age, that is to say, according to the point that they have reached in that long career that they are destined to run.

Gentlemen, this idea of evolution, with a sense very analogous to that which we now attach to it, we already find a presentiment of in the Greek schools. There is nothing surprising in this, for these admirable schools agitated all ideas, took up all problems, and foreshadowed the greatest truths of the phenomena of nature with wonderful intelligence. In them we find the origin of our opinions and of our scientific methods, just as our arts find in them their highest expressions and most perfect models.

During the middle ages a doctrine of evolution could not arise. The conception of a universe formed of a substance derived from the vicissitudes of our terrestrial world was absolutely opposed to it. But with the Renaissance our doctrine was to obtain its firmest base and most magnificent developments. Then, gentlemen, was discovered the most wonderful instrument that man has possessed for studying the heavens, and this instrument was in the hands of a most penetrative genius; you have already named Galileo and the astronomical telescope.

With his cardboard telescope and its simple lens as large as a five franc piece, Galileo discovered the world of Jupiter, the phases of Venus, the mountains of the moon, etc. The similitude of the planets with the earth in form, motion, and physical constitution was at once revealed. Galileo taught us that these simple, brilliant dots were globes that showed the presence of continents, atmospheres, and satellites like our own.

In a word, the planets are stars like the earth, and are seen from the earth as the latter would be seen from one of them.

Gentlemen, from the standpoint of our doctrine of evolution, these facts had an immense import. Since the planets are in all respects like the earth, their origin must be the same, and the phases that the earth will undergo during its existence they will undergo in theirs. Here, then, we have the idea of evolution leaving the earth and taking possession of the solar system.

At the same time, gentlemen, another genius as great as the Italian one, but perhaps a calmer, serener spirit, Descartes, formulated an idea of astonishing profoundness that embodies the origin, past, and future of the earth, and its relations with the sun. "The earth," says he, "is an incrusted sun," which signifies that it has been a globe of fire just as the sun now is, and that it is the smallness of its mass as compared with that of the sun that has produced a more rapid cooling, whence has resulted the formation of a solid surface, the oceans, and the atmosphere, that is to say, its constitution as a planet. Now associate the brilliant discoveries of Galileo and the profound views of Descartes, and you will rise to the genesis of the solar system in its entirety.

So, gentlemen, there is the idea of natural formation and evolution that is now in possession of our planetary world. How will it result? How will it make the conquest of the heavens? Gentlemen, for this it is necessary to wait for more than a century, to leave the south and go toward the climates of the north. There, toward the middle of the eighteenth century, arose a man who was the most industrious and perhaps the greatest observer that has ever existed; a man who, starting from a modest and entirely different career, was self-educated in science, and invented the instruments and methods that he used; a man who, himself alone, effected a number of discoveries capable of making ten reputations, and who, as a legitimate reward, was to see his name become the symbol of astronomy among his contemporaries, and his ideas received as the truths of science itself. It was William Herschel.

Among the immense labors of Herschel, we shall consider only those on the nebulæ, because it was through the conclusions that he drew from his observations on these that the idea of evolution entered the heavens. Herschel, alone, discovered the best portion of the nebulary heavens. He found 70 or 80 of them, he leaves us 2,500. From the extensive review that he made of these stars, with often so strange forms, he evolved a great and magistral idea, which he made his own, and which has since become popular. Every one knows this idea, so much has it pleased minds by its simplicity and grandeur.

It is as follows: The nebulæ often exhibit brilliant points, which, if instead of being considered in a single nebula, be examined in a large number of these stars, show themselves to be surrounded by more or less extensive nebulosities. It seems that these nuclei offer us all degrees of condensation of the matter of which they are formed, from the most diffuse cloud up to the best formed star. The idea that then presented itself to Herschel's mind was that the nebulæ show us worlds in the process of formation. According to this, then, the stars would be merely nebulous matter that has condensed and given rise to suns and to the bodies that move in their train.

You see, gentlemen, upon what general facts Herschel based his theory. It was not by considering a single nebula that he could justify it. In fact, in order to look on the transformations that result in the formation of a star, starting from the nebular cloud, it would be necessary to have periods at our disposal before which life, and doubtless human science, represents but an instant. No; it was through the consideration of a series of stars in which the transformation existed in various degrees. Herschel imitated the naturalist who, in passing through a forest, observes trees of the same species of different ages, and, from his observations, deduces the cycle that the plant has traversed at the various periods of its existence. The significance of this theory is far-reaching.

In the first place, it makes us see worlds in continual formation, thus completely changing the ideas that once obtained as to the universe. Next, by explaining to us a mode of formation of the worlds, it opens for us an extensive programme of research and meditation.

Behold, then, gentlemen, the idea of formation and evolution in the stars that has crossed the horizon of our solar system to spring at a single bound to the last limits of the universe that are accessible to us.

It now remains to see how we shall fill that immense gap that separates our planetary world from the nebulæ, that is to say, how the idea of evolution will seize on the world of stars.

(To be continued.)

[MINING AND INDUSTRIAL ADVOCATE.]

GEOLOGY EXPLAINED IN THE SIMPLEST FORM.

IT is not so difficult as you might suppose to read the contents of stones. Let us see.

Take three pieces of stone:

1. A piece of sandstone.
2. A piece of granite.
3. A piece of chalk.

You are quite familiar with each of these kinds of stone. Sandstone is a common material for walls, lintels, hearths, and flagstones. Granite may now be frequently seen in polished columns and slabs in public buildings, stores, and tombstones, and the streets in many large cities and towns are now paved with it. Common white chalk is well known to everybody.

Take the piece of sandstone in your hands and examine it carefully, using even a magnifying glass if the grains are minute. Then write down each of the characters you observe, one after another. You will of course pay little heed to the color, for sandstones, like books, may be red or white, green or yellow, or indeed of almost any color. Nor will you give much weight to the hardness or softness as an essential character, for you may find even in a small piece of the stone that one part is quite hard, while a neighboring place is soft and crumbling.

If your piece of sandstone is well chosen for you, you will be able to write down the following characters:

1. The stone is made up of small grains.
2. The grains are all more or less rounded or worn.
3. By scraping the surface of the stone, these rounded grains can be separated from the stone, and when they lie in this loose state, they are seen to be mere grains of sand.
4. More careful examination of the stone shows that the grains tend to lie in lines, and that these lines run in a general way parallel with each other.
5. The grains differ from each other in size and in the material of which they are made. Most of them consist of a very hard, white or colorless substance like glass, some are perhaps small spangles of a material which glistens like silver, others are softer and of various colors. They lie touching each other in some sandstone, in others they are separated by a hard kind of cement, which binds them all into a solid stone. It is this cement which usually colors the sandstone, since it is often red or yellow, and sometimes green, brown, purple, and even black.

Summing up these characters in a short definition, you might describe your sandstone as a stone composed of worn, rounded grains of various other stones arranged in layers.

Proceed now in the same way with the piece of granite. You find at once a very different set of appearances, but after a little time you will be able to make out and to write down the following:

1. The stone contains no rounded grains.
2. It is composed of three different substances, each of which has a peculiar crystalline form. Thus one of these, called feldspar, lies in long, smooth faced, sharply defined crystals of a pale flesh color or dull white, which you can with some difficulty scratch with the point of a knife. These are the long, white, sharp edged objects that are easily seen. Another, termed mica, lies in bright, glistening plates, which you can easily scratch, and split up into thin, transparent leaves. If you compare these shining plates with the little silvery spangles in the sandstone, you will see that they are the same material. The third, named quartz, is a very hard, clear, glassy substance, on which your knife makes no impression, but which you may recognize as the same material out of which most of the grains of the sandstone are made.
3. The crystals in granite do not occur in any definite order, but are scattered at random through the whole of the stone.

Here are characters strikingly different from those of the sandstone. You might make out of them such a short definition as this: Granite is a stone composed of distinct crystals, not laid down in layers, but irregularly interlaced with each other.

Lastly go through the same process with your piece of chalk. At first sight this stone seems to have no distinct character at all. It is a soft, white, crumbling substance, soils your fingers when you touch it, and seems neither to have grains like the sandstone nor crystals like the granite. You will need to use a magnifying glass, or even perhaps a microscope, to see what the real nature of chalk is. Take a fine brush and rub off a little chalk into a glass of clear water, then shake the water gently and let it stand for a while until you see a layer of sediment on the bottom. Pour off the water, and place a little of this sediment upon a piece of glass, and look at it under the microscope or magnifying glass. You will find it to have strongly marked characters, which might be set down thus:

1. The stone, though it seems to the eye much more uniform in its texture than either sandstone or granite, is made up of particles resembling each other in color and composition, but presenting a variety of forms.
2. It consists of minute shells, pieces of coral, fragments of sponges, and white particles, which are evidently the broken down remains of shells, under a microscope which magnifies them fifty times. Large and well preserved shells, sea urchins, and remains of other sea creatures occur embedded in the chalk.

As a brief description of chalk, you might say that it is a stone formed out of the remains of once living animals.

You should repeat this kind of examination again and again, until you get quite familiar with the characters which have been written down here, and you will see why it is important for you to do so when you come afterward to find out that these three stones are examples of the three great groups into which most of the rocks of the world may be arranged. So that when you moisten the composition of a piece of sandstone, or chalk, or granite, and learn how each stone was formed, you not only do that, but lay a foundation of knowledge which will enable you to understand how by far the greater part of the stones of our mountains, valleys, and sea shores came into existence.

In spite, then, of the apparently infinite diversity of the stones of which the globe is built up, you see that by a little study they may be grouped into very few classes. You have to follow a simple principle of classification, and each stone you may meet with falls naturally into its own proper group. You do not concern yourselves much with mere outer shape and line, but try to find out what the stone is made of, and ask whether it should be placed in the sandstone group, or in the granite group, or in the chalk group.

Sediment.—We take a glass of water and put some gravel into it. The gravel at once sinks to the bottom and remains there even though we stir the water briskly. We close the mouth of the glass and shake it up and down so as to mix the water and gravel thoroughly together; but as soon as we cease to do so and place the glass on the table again, we see that the gravel has sunk and formed a layer at the bottom. This layer is a *sediment of gravel.*

Instead of gravel, we put sand into the water and shake them up as before. We mix them so completely that for a moment or two after we cease, the water seems quite dirty. But in a few minutes the sand will have sunk to the bottom as a layer below the water. This layer is a *sediment of sand.*

We take a little mud or clay, instead of either the gravel or sand, and shake it up in the water until the two are thoroughly mixed. When the glass is replaced on the table this time, the water continues quite dirty. Even after some hours it remains still discolored, but we see a layer beginning to appear at the bottom. If the glass is allowed to stand long enough undisturbed, that layer will go on growing until the water has again become clear. In this case the layer is a *sediment of mud.*

Sediment, therefore, is something which after having been suspended in, or moved along by, water has settled down upon the bottom. The coarser and heavier the sediment, the quicker will it sink, while when it is very fine it may remain in suspension in the water for a long time.

Sedimentary rocks must thus be those which have been formed out of sediments. And just as sediments differ from each other in coarseness or fineness, so will the sedimentary rocks formed out of them.

Take three pieces of sedimentary rocks: a piece of *conglomerate* or pudding stone, the piece of *sandstone* you have already looked at, and a piece of *shale.* Examine the first of these three pieces. You find it to be made of rounded little stones, firmly cemented together. Were these round stones to be separated from each other, and gathered into a loose heap, you would call it a heap of gravel. The stone is evidently nothing more than a hardened gravel, such as you might pick up on the seashore or in the channel of a stream. It is sometimes called pudding stone, because the stones lie together, somewhat like the fruit in a plum pudding.

Take up the piece of sandstone again, and make a further examination of it. Did you ever see anything like the grains of which it is made up? You reply that they are mere grains of sand, such as might be met with anywhere. And you are quite correct. The sandstone consists of nothing else but sand firmly held together so as to form a stone. If you went down to the

seashore, on to the bed of a brook, or river, you would gather sand of very much the same kind, and by hardening such sand into a compact mass, you might make sandstone.

In the third specimen you cannot so easily make out what the grains of the stone are, since their size is so small. But take a knife and scrape a little off the end of the stone and work it up with some drops of water; you will make a kind of paste in this way. Then put this paste into a tumbler of water and stir it well round. Immediately the water gets dirty-looking, and remains so even for some time afterward. But put the tumbler aside for some hours, and you will find that the water becomes clear again; that what you put in as a dirty paste has sunk to the bottom of the glass as a layer of sediment, and that it is simply mud. The shale, therefore, is nothing more than a stone formed of fine muddy sediment, just as the conglomerate is formed out of coarse gravelly sediment.

The term sedimentary rocks is a very expressive one, for it includes stones formed of all kinds of sediment, whether coarse or fine.

POT VINES.

THE vines represented in the illustration herewith were grown in 10 inch pots, and started on the 15th of January, coming into fruit on the 11th of June following. Seven pot vines bore forty-seven bunches of grapes, and from each vine I cut on the average 8 lb. of fruit, and the average weight of each bunch was 1 lb. The plants occupied a three-quarter span-roofed pit 7 feet high and 18 feet long. To the well ripened wood was this excellent result due. The plants broke at every eye, and were liberally syringed, as Mr. Coleman advised, to secure free setting of the grapes. The berries swelled satisfactorily and the bunches finished off as well as possible. As to the soil used, I may state that it was good turfy loam with a mixture of lime rubbish and a little charcoal, as no liquid manure was given, but an occasional dressing of artificial manure and fresh horse manure.—*Alexander Trail, the Garden.*

BARBERRIES.

IN addition to the gorgeous spring display furnished by Darwin's barberry (Berberis Darwini), it is at times of considerable value as an autumn and early winter flowering shrub, for should the weather be mild, it is often possible to find some specimens quite laden with bloom during these seasons. It is, in fact, one of our most ornamental shrubs, as, irrespective of flowers, the dark, glossy evergreen foliage is very handsome, and toward the end of the summer an additional feature is supplied by the purple berries, which in some cases are borne in great profusion. They are about the size of large peas, and covered with a delicate bloom like a well-finished grape. Though discovered by the late Mr. Charles Darwin, we are indebted to Mr. William Lobb for its introduction, and, notwithstanding the great number of plants introduced by him to our gardens, it is impossible to point out a more useful one than this.

The small-growing South American Berberis empetrifolia, though pretty when in a flourishing condition, is of a delicate constitution, its principal claim to recognition being the fact that it is regarded as one of the parents of B. stenophylla, which may well dispute with Darwin's barberry the honor of being the most ornamental of all barberries. Though always spoken of as a hybrid, I must confess that its early history is unknown to me, but perhaps some of the readers of the *Garden* will be able to supply the information. Anyhow, it is an extremely handsome shrub, and when planted in such a position that there is plenty of room to display its true character, the long arching shoots dispose themselves in a very graceful manner, and when wreathed with golden blossoms they present a gorgeous sight. This may be treated as a wall shrub, and if there is plenty of space for the long shoots to develop themselves, it is seen to great advantage grown in this way. Of the deciduous-leaved barberries, a high place as an ornamental shrub must be assigned to the common kind, which, in addition to the spring floral display, is so handsome when laden with fruit. The extremely bright color of the berries and the length of time they remain in beauty, combined with the robust character of the plant and its almost total indifference to soil or situation, render it of great value to the planter. There are a couple of varieties differing in the color of their berries from the normal type, one being of a whitish tint and the other purple. A well-marked and valuable variety is the purple-leaved form, which in a sunny spot acquires a depth of color equal to that of the purple leaved beech. With the change in the color of its foliage this variety maintains the vigorous character of the type.

A large, bold-growing kind is the Himalayan B. aristata, something like an unusually vigorous form of the common barberry, but it is very much later in flowering than that kind. The reddish color of the leafless branches during winter causes it to stand out conspicuous at that season, and this, combined with the fact that it does not bloom till most flowering shrubs are past, renders it all the more valuable. The flowers of the Chinese barberry (B. sinensis), a thick-growing bush densely clothed with small roundish leaves, make their appearance just as the branches are studded with the delicate green, partly expanded foliage. They depend in great profusion from the under sides of the twigs, and in color are sulphur yellow inside and a sort of brownish crimson on the outside. It is altogether a pretty little shrub, as the neat, fresh green foliage is very pleasing, and in the autumn it assumes a bright red tint. The little oblong-shaped, sealing-wax-like fruits are, as a rule, sparsely borne. To the evergreen species mentioned in the first part of this article must be added the little Himalayan B. concinna, which is well fitted for the rockery, as it is of too fragile a nature to associate with the other strong-growing kinds. The slender branches are clothed with neat foliage, light green above and of a beautiful silvery whiteness underneath. The pale yellow flowers are borne during the latter half of the summer. B. Wallichiani, of which an illustration is here given, is a seldom seen kind, yet it is a very ornamental one. The stout, spiny branches are clothed with deep glossy evergreen foliage, which serves as a very effective setting to the clear yellow blossoms. This species is a native of the Himalayas, and unless in very severe winters is quite hardy around London.

POT VINES.

BERBERIS WALLICHIANA.

The Mahonia section of berberis includes among its number some very ornamental kinds, the commonest and withal one of the most valuable being M. aquifolium, which is one of the best shrubs for forming undergrowth beneath trees. Besides this, it is extremely handsome as a specimen shrub, that is if a good form be chosen, for where raised from seed in quantity it is possible to pick out some greatly superior to others.

M. fascicularis is even still more showy when in bloom, the clusters of flowers being, as a rule, more numerous. The common Mahonia when in an open position has the foliage more or less suffused with a bronzy hue, and in some specimens it is strongly marked. When in this state it is very useful for cutting, as the leaves last a long time in water, and look well along with chrysanthemums in vases or similar purposes. There are several tall, stately growing species among these pinnate-leaved Mahonias, of which some of the Himalayan kinds are rather tender. The hardiest, and therefore by far the most useful to the planter, is M. japonica, whose lemon-colored blossoms will, during mild winters, make their appearance by the end of February, and be succeeded by berries as large as small grapes. At all times the stately character of the plant and the long pinnate leaves, of a stout leathery texture, stamp it as quite distinct from the general run of hardy shrubs.—*T., in the Garden.*

A HOME-MADE INCUBATOR.

P. H. JACOBS.

WITH the aid of the illustrations but little difficulty need be experienced in making an incubator, and as the one here described is in general use, it has been fully tested and found to perform all that may be reasonably expected. Fig. 1 represents the *interior* of the incubator.

It will be noticed that there are an outer and inner box, with sawdust between them—chaff or any such material will answer. The outer box is 48 inches long, 44 wide, and 36 high. The inner box is 40 inches long, 32 inches wide, 18 inches deep, and holds a tank 32×36 inches. The outside measurements are used in measuring boxes. A is the outer box and B the inner. C C are strips one inch wide and one inch thick, with iron rods, ⅝ of an inch thick (F F), upon which the tank rests. D D are similar strips (but no rods) for supporting the egg drawer. E is a 1½ inch tin tube, two feet long, which admits air into the ventilator (space under egg drawer). The ventilator is five inches deep, and is of the same length and width as the tank. Fig. 2 shows a sectional plan.

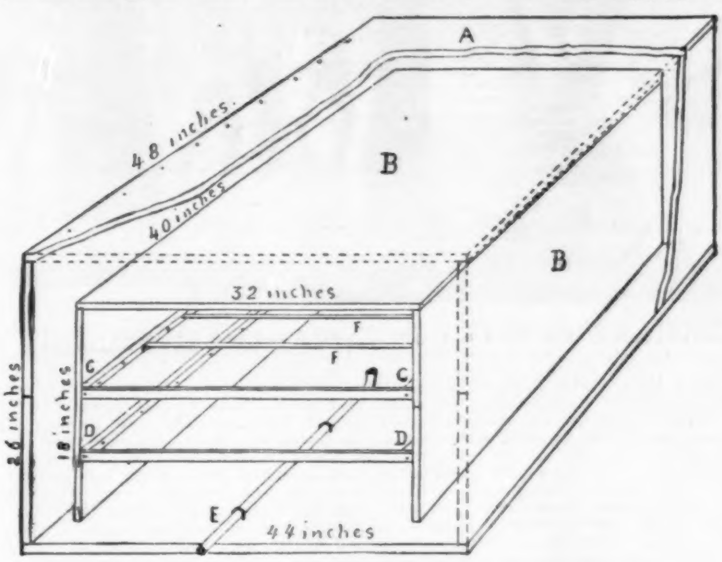


FIG. 1.

A is a tube extending through the incubator into the tank. B is a faucet for draining off water. C is the egg drawer. D is the tin air tube. The egg drawer, Fig. 3, is four inches deep, outside measurement, and should be made of light material. It is 39 inches long and 30 inches wide, containing three movable trays, 1½ inch deep, and of size to fit in the drawer. The bottoms are thin strips (one inch wide and one inch apart, to both drawer and trays), over which muslin is tightly drawn and tacked. The tank is seven inches deep. The faucet is detachable, and screwed in when desired, on a thread. The tube on top is seven inches high. The front of the egg drawer is also boxed off and filled with saw-dust.

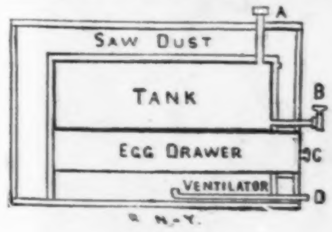


FIG. 2.

It requires about 115 feet of lumber (inch tongued and grooved boards), and the cost of the tank is about $5. The plan of the tank is shown at the sectional view given. When completed, the incubator is simply a box, having this appearance. See Fig. 4.

In building one may follow any plan that may be preferred, as it is not necessary to conform to any particular design. Have the floor close. All that is necessary is to make a *warm room* for keeping the eggs at a uniform temperature; but do not attempt to have any tubes for the escape of air. Opening the drawer to turn the eggs provides sufficient ventilation.

DIRECTIONS FOR OPERATING.

Each tray holds about 80 eggs, laid in promiscuously, the same as in a nest, making the total number for incubator 240 eggs. First fill the tank with *boiling* water, but never allow it to remain in the tube on top, as it thus increases pressure; hence, when the tank is full to top of tube, draw off a gallon of water. Fill it

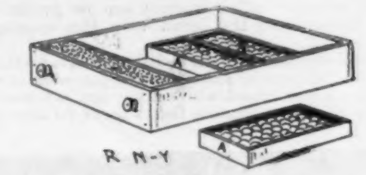


FIG. 3.

48 hours before putting eggs in, and have heat up to 115° before they are put in. As the eggs will cool down the heat, do not open the drawer for six hours, when the heat should be 103°, and kept as near to that degree as possible, until the end of the hatch. It is best to run it a few days without eggs, to learn it thoroughly. Place incubator in a place where the temperature does not fall below 60°. As the heat will come up slowly, it will also cool off slowly. Should the heat be difficult to bring up, or the eggs be too cool, you can raise or lower the trays, using small strips under them. You can also stop up or open the air tube in the front opening of the ventilator whenever you desire. When the eggs are put in, the drawer will cool down some. All that is required then is to add about a bucket or so of water once or twice a day, in the morning and at night, but be careful about endeavoring to get up heat suddenly, as the heat does not rise for five hours after the additional bucket of water is added. The cool air comes from the ventilator pipe, passing through the muslin bottom of the egg drawer to the eggs. Avoid opening the egg drawer frequently, as it allows too much escape of heat, and be careful not to open it when chicks are hatching, unless compelled, as it causes loss of heat and moisture at a critical time. Cold draughts on the chicks at that time are fatal. Do not oblige visitors. Be sure your thermometer records correctly, as half the failures are due to incorrect thermometers, and not one in twenty is correct. Place the bulb of the thermometer even with the top of the eggs, that is, when the thermometer is lying down in the drawer, with the upper end slightly raised, so as to allow the mercury to rise, but the bulb and eggs should be of the same heat, as the figures record the heat in the bulb, and not in the tube.

Turn the eggs twice a day at regular intervals—six o'clock in the morning and six o'clock at night. Do not let them cool lower than 70°. Turn them by taking a row of eggs from the end of the tray and placing them at the other end, turning the eggs by rolling them over with your hand. By removing only one row you can roll all the rest easily. Give no moisture the first week, very little the second, and plenty the third week. Do not sprinkle the eggs. For moisture, put a wet sponge, the size of an egg (placed in a flat cup), in each tray, the second week, and two sponges in each tray the third week. Do not put in sponges until you are about to shut up the drawer, after turning. Wet the sponges by dipping in hot water. After the first ten days the animal heat of the chicks will partially assist in keeping the temperature. Be careful, as heat always drops when chicks are taken out. You can have a small glass door in front of the egg drawer, to observe thermometer, if desired.

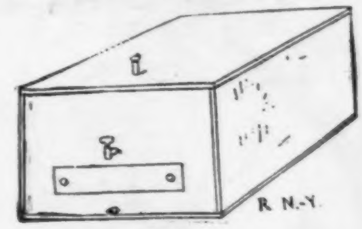


FIG. 4.

Always change position of trays when the eggs are turned, putting the front one at the rear. After the fourteenth day spray the eggs twice a day with water warmed to 110 degrees, using an atomizer, and do it quickly.—*Rural New-Yorker.*

OBSERVATIONS ON THE FEMALE FORM OF PHENGODES LATICOLLIS HORN.

ENTOMOLOGISTS will remember the interest taken about one year ago, in the discovery that the female form of a Lampyrid* (*Zarhipis riversi*) was larva-like, and that the three stages—larva, pupa, and adult—differed but little. On the night of September 27, 1886, a larviform luminous beetle was collected on one of the walks of the campus of the University of North Carolina.

Pupa State.—As the insect cast its skin only once—in the spring of 1887—after coming into my possession, this must represent its pupa state.

Description.—Length when crawling, two and three-fourths inches; width, three-eighths inch. Flattened, larviform, luminous; composed of twelve segments (exclusive of the head), tapering gently behind, and more decidedly on the three anterior segments. Chitinous plates on dorsum blackish brown, the second to eleventh inclusive with a pair of large, light brown, oval spots. Anal plate light brown, except a median band of blackish brown, convex behind. First plate light brown, except a median irregular and two lateral blackish brown spots. Below each stigmata, on the fourth to the eleventh segments inclusive, are two longitudinal folds, the anterior half of each fold blackish brown, shading into light brown in the middle, and becoming yellowish white, with an olive tinge on the posterior half. Posterior edge of each dorsal plate dark olive brown; the posterior angles of the pro, meso, and meta thoracic plate and the anterior third of the pro-thoracic plate yellowish white, tinged with olive. On the fifth to ninth segments inclusive (ventral surface) are one pair each of small, elongated, black dots, corresponding very nearly in position with the pairs of luminous organs of the ventral surface. Anal proleg blackish brown above, yellowish white below.

Besides the stigmata on the fourth to the eleventh segments, there is one on the ventral surface of each

PHENGODES LATICOLLIS, SHOWING LUMINOSITY.

anterior corner of the meso-thoracic segment; also two pairs of small dorsal spiracles, one each between the fourth and fifth and fifth and sixth segments.

Thoracic legs brown, suffused with yellowish olive. Tarsus two-jointed; single claw curved. Anterior edge of femur with a row of short hairs; under edge of tibia and first joint of tarsus with a similar row of hairs; under edge of last joint of tarsus with small, short papillæ. Head black, 2½ mm. in width, retractile. Mandibles curved, sickle-shaped, black. Antennæ four-jointed; labial palpi two-jointed (or three-jointed? Those of a larva collected in July appear three-jointed); maxillary palpi four-jointed.

The location and form of the phosphorescent lights are as follows: On each side is a row of circular ones, one on each segment from the second to the twelfth inclusive. Each of these is nearly one-eighth inch in diameter, and situated in the posterior end of the upper longitudinal fold. The posterior edge of each segment, from the second to the twelfth inclusive, emits a band of light. On the under surface are five pair, mere points, one pair each on the fifth to ninth segments.

The general appearance is that of a worm beautifully illuminated with bluish white lights, which are disposed in a longitudinal row on each side, and in transverse bands.

The insect was placed in a small, elongated vial, so that I might easily observe and exhibit the display of lights. The light was brilliant until 11 P. M. on the night of September 27. At 2 A. M., the 28th, the phosphorescence had disappeared. It did not appear again until the night of the 30th, when, by disturbing the insect, the lights began to glow, but continued only for a few hours. For a few nights within the space of a week I observed that the insect glowed only when disturbed. After that the phosphorescence reappeared, and I do not believe once disappeared again until it was placed in alcohol, June 16, 1887.

October 1, 1886, I placed it in a glass jar of earth. It made a cell in the earth next the side of the jar, where I could observe the phosphorescence, and where it remained (excepting one warm day in February, 1887, when it came to the surface, and returned at night, when I placed the jar in a cooler place in my room) coiled up until the 15th of April. At that time the luminosity was becoming more brilliant and the brown color was disappearing, to be replaced by a uniform cream color.

I removed the earth from above the cell and took the

* Am. Nat., xx., 648. See also Ent. Am., iii., 208.

insect in my hand. It immediately straightened and began crawling. When placed in the jar, it sought its cell and there remained. Instead of returning the earth, I placed a glass over it, so that I might observe the beautiful display of light. It was so strong that I could read print by it when the letters were one-eighth inch long. About the 1st of May it cast its skin and became of a uniform cream color, lighter on the sides and ventral surface and between the segments of the dorsum.

Every night it came from its cell and wandered about the jar, probably striving to attract its mate. May 8 I took it out of doors at night, and placed it on the ground for about fifteen minutes. Nothing was attracted. Twice I took it in the day time—the 10th and 12th of May—but nothing was attracted.

May 19 I placed it, with another (collected by Professor Holmes), in a large, open glass jar, with about one inch in depth of earth. This I partly sunk in the earth in the open woods just at dusk. At nine o'clock the same evening I visited the place and saw a male within the jar. When it left its mate I caught it.* On the following morning I found another male outside the jar. The following night I captured two more males. During the day the females remained beneath the surface of the earth.

The luminosity in this case is decidedly of sexual significance, attracting the males at night. Mr. Rivers concluded that the luminosity of the female *Zarhipis riversi* was not of sexual significance, as males were attracted by day. He was at a loss to account for its utility.

Soon after meeting with the males the females became less active and the luminosity, though plainly visible, was less in brilliancy. About June 4 they made each a cell in the earth and began depositing eggs. One deposited about twenty, and the other about thirty-five. The eggs are dull whitish in color, 3 mm. to 4 mm. in diameter. This, I believe, is the first instance on record of the eggs of any of the *Phengodini*. The female is coiled up in the cell while depositing the eggs, and afterward lies coiled up on them. They are then very weak, and soon die. Can it be that the parent yields its dying or dead body as the first meal for its young? One which was found in September, 1886, was taken from the eggs when nearly dead and placed in alcohol. The eggs of this one proved infertile. The mouth parts, and especially the legs, were very much atrophied, and description was well nigh impossible. In general appearance the adult is very much like that of the larva and pupa. The two which I observed did not, however, resume the dark brown color, but remained of a uniform pale cream color, lighter on sides, under parts, and between the segments of the dorsum.

Occasionally during the adult state the one which I kept through the winter showed signs of luminosity on the prothoracic segment, but mainly shone as represented. The other one exhibited no sign of luminosity on the pro and meso thoracic segments. Otherwise it was like the figure. Professor Riley, seven years ago, figured a similar phosphorescent insect,† and in the paper read before the Washington Entomological Society he says that one found by him in 1869 was figured in Le Baron's fourth Illinois report.

The males are insignificant when compared to the females in size and beauty. They are 15 mm. to 20 mm. in length. Antennæ plumose, and half, or more than half, as long as the body. The elytra are short, thin, and subulate.

GEO. F. ATKINSON.

Univ. of North Carolina, Chapel Hill, July 7, 1887.

—*Amer. Naturalist.*

EXPERIMENTS UPON THE COLOR RELATION BETWEEN PHYTOPHAGOUS LARVÆ AND THEIR SURROUNDINGS.

By E. B. POULTON.

FROM the instance of the larval *Smerinthus ocellatus*, I have shown that certain Lepidopterous larvæ are susceptible to the influence of surrounding colors, so that the larvæ themselves gain a corresponding appearance.‡ This larva varies from bright yellowish green to a dull whitish or bluish green, and either variety can be produced by the use of a food plant, with the appropriate color on the under side of the leaves.

Although the difference between the two varieties is very great when they are placed together, so great in fact that I can readily distinguish three intermediate stages of variation between the extremes, yet it is not nearly so well marked as in the case of the green and brown varieties of many dimorphic larvæ. I was therefore anxious to test one of these latter, and to ascertain whether either variety can be produced at will by surrounding the larva with the appropriate color.

Lord Walsingham had previously called my attention to the variable larvæ of *Rumia cratægata*, some of which are brown, some green, while many are intermediate. The larva exactly resembles the twigs of its food plant, and always rests upon the branches in a twig-like attitude, and this habit rendered the species very favorable for the purpose of this inquiry, which was conducted as follows; A glass cylinder was provided with a black paper roof, and a similar floor, and a small quantity of the food plant—hawthorn—the rest of the space being entirely filled with dark twigs. Owing to their habit the larvæ always rested upon these latter, and after reaching maturity in two such cylinders, forty dark varieties were produced. Three other cylinders were roofed and floored with green paper, and green shoots bearing leaves were introduced as food, nothing brown being allowed inside the cylinder. In these cylinders twenty-eight green varieties were produced. The young larvæ were obtained from the eggs of three captured females.

After hatching, the larvæ were thoroughly mixed and introduced into the cylinders when quite small. Some of the dark varieties were greenish, and some of the green larvæ brownish, but the greenest in the dark cylinders was browner than the brownest in the green cylinders. The larvæ were compared by placing the sets side by side upon white paper, and the contrast between the larvæ brought up in different surroundings was very marked. In this case the larvæ ate precisely the same kind of leaf, so that it is clear that the effects follow from the surrounding colors, and not from the action of food.

The instance recorded above is the best among the many cases of adjustable color relation which are now known in Lepidopterous larvæ. It is now extremely probable that all dimorphic species will show more or less of this susceptibility to the colors of their environment.

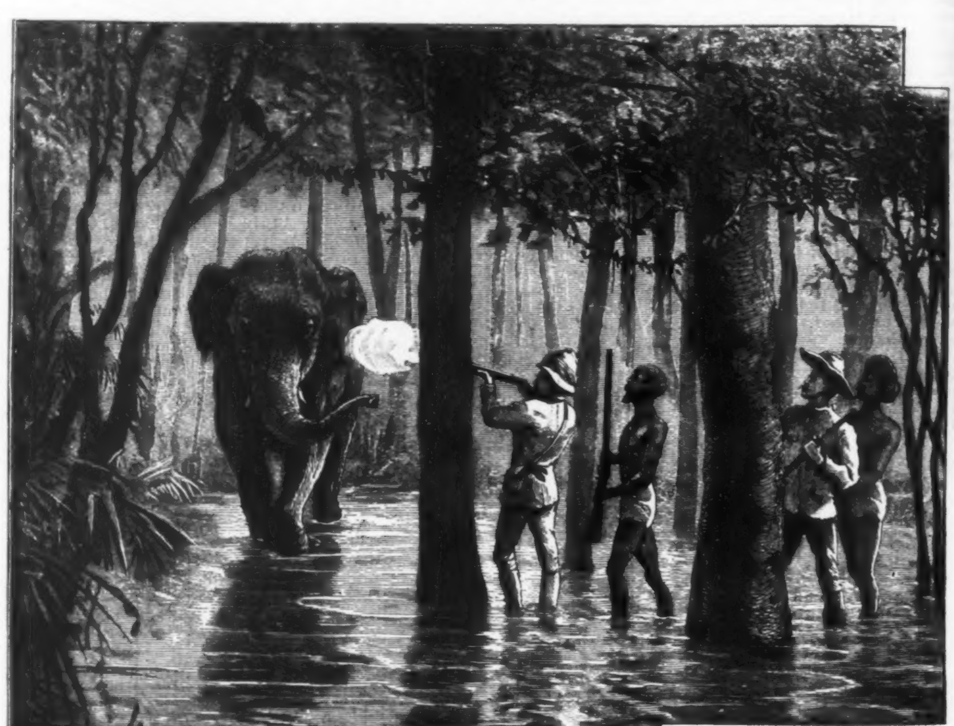
* Determined by Professor Riley as *Phengodes laticollis* Horn.

† American Entomologist, vol. iii.; new series, vol. i., 1880, p. 202.

‡ An account of these experiments will be found in Proc. Roy. Soc., No. 237, 1885, p. 269, and No. 243, 1886, p. 135.

AN ELEPHANT HUNT IN CEYLON.

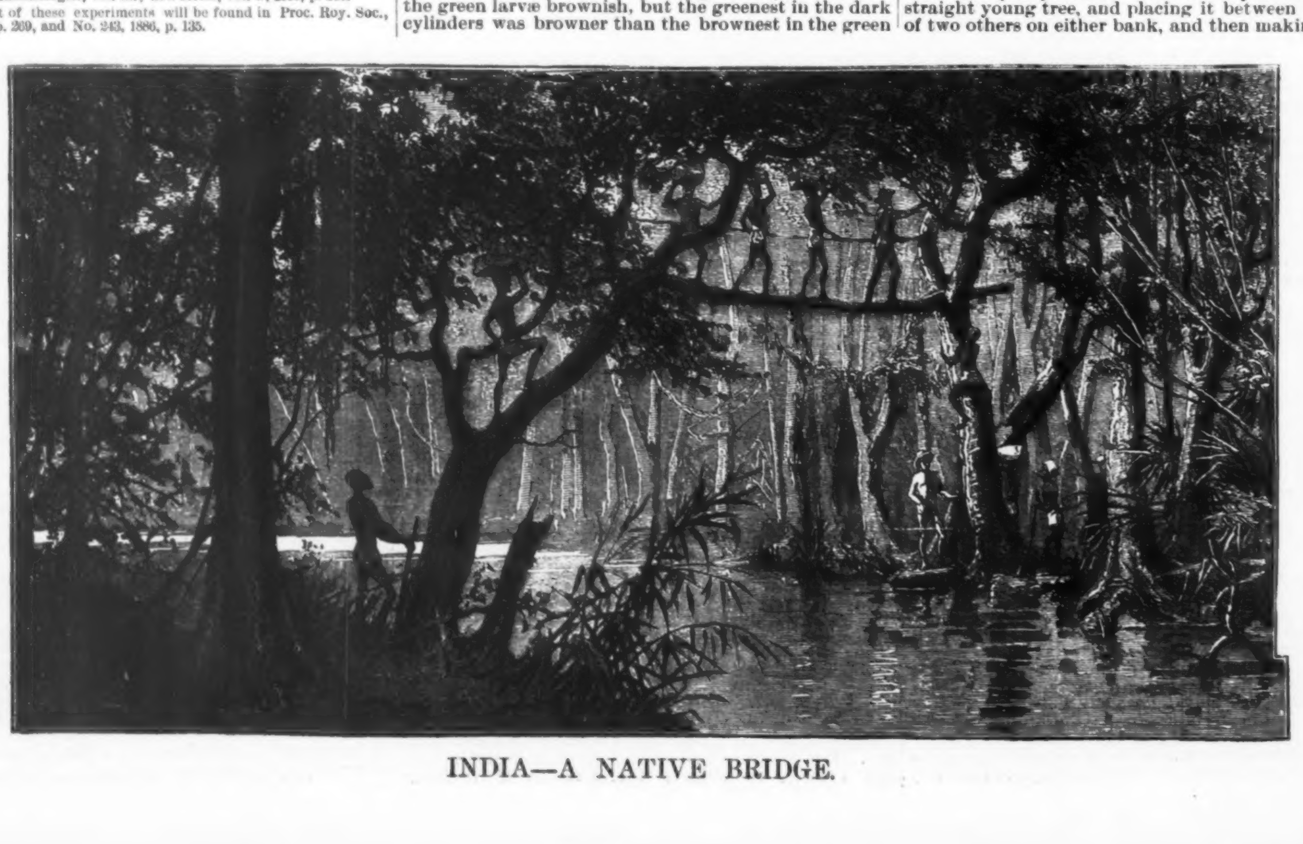
HAVING obtained the necessary licenses, "M. W. M." (to whom we are indebted for the sketches from which



ELEPHANT HUNTING IN INDIA—THE FIRST SHOT.

our engravings are taken) quitted Trincomalee on a sunny August afternoon, accompanied by two old friends, their servants, and a gang of coolies. They embarked on board two Kottiar canoes, and after a short and pleasant trip arrived at the pretty little Moor village of Kottiar, which has a lovely background of cocoanuts, palmyras, and tamarind trees. Their ultimate destination was Kanda Kadu, about fifty miles distant, where they had heard from their noted trackers, Allah Pitchei and Sinnacooty, that a "rogue" elephant had lately been seen, and had been committing serious depredations. Next day they started, some going in canoes, and some walking along the banks of the Mahawelliganga River, which is the finest in the island. The scenery along the banks is most varied and beautiful, but the stream itself abounds with large and ferocious crocodiles, which made fording rather unpleasant work.

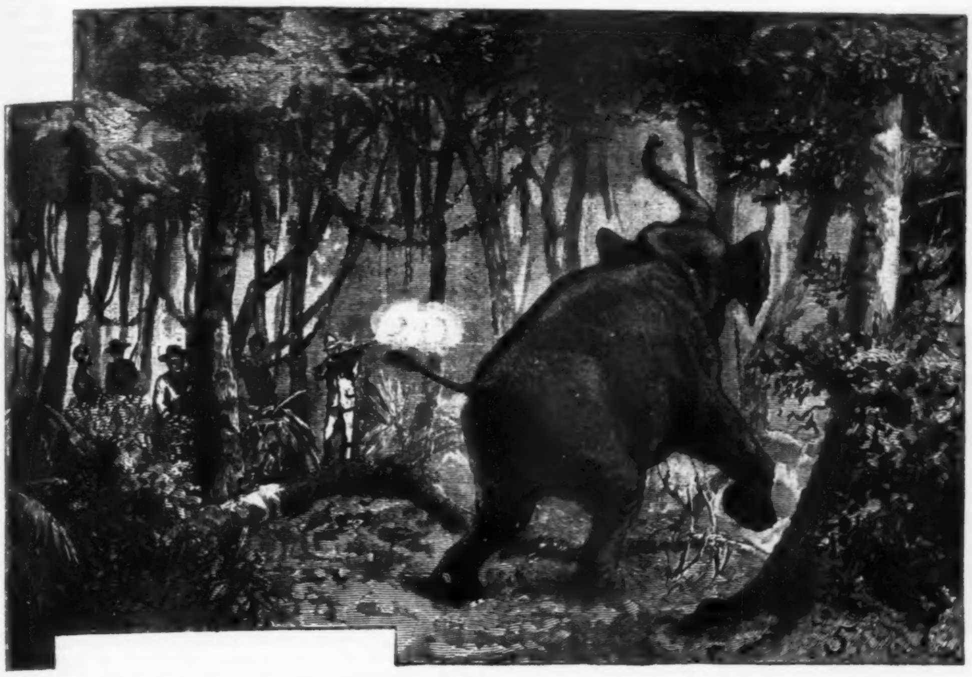
The deeper places were crossed by cutting a fairly straight young tree, and placing it between the forks of two others on either bank, and then making a hand-



INDIA—A NATIVE BRIDGE.

rail of jungle rope. Only once did they have an accident. A coolie slipped and fell into the water, losing a precious case of provisions, but the man himself was saved. Having arrived at Kanda Kadu, they pitched their tents, fixed their camp beds, and had a most enjoyable supper and sleep. Rising early next morning they found their trackers already on the alert, and engaged a Veddah (one of the wild men of the woods) who offered his services. These Veddahs are a peculiar race. They are most willing, hardworking, and very courageous. They live on honey and whatever else they can capture by the aid of their bows and arrows and a small ax, without which they are never seen.

Now began the march after the "rogue" elephant. The party traversed an almost impenetrable jungle consisting of scrub and thorn bushes, besides being up to their waists in water. After wading through this quagmire for three hours they emerged from it, and soon after had just time to slip behind one or two good trees, when the animal they were in search of came straight at them. "M. W. M.," having won the toss, took first shot and gave the foe the contents of his twelve bore rifle at twelve paces just over the eye. The wounded creature threw up his head, turned tail, and fled, trumpeting loudly, and smashing everything in his headlong career. After an exciting chase of twenty minutes "M. W. M." was again lucky enough to be first in the field, and with a well directed shot placed just behind the ear the monster toppled over dead, close to a jungle palm. After taking the brush the sportsmen drank their own very good healths, and were not sorry for a refresher after so long a chase under the rays of a tropical sun.



ELEPHANT HUNTING IN INDIA—THE SECOND SHOT.

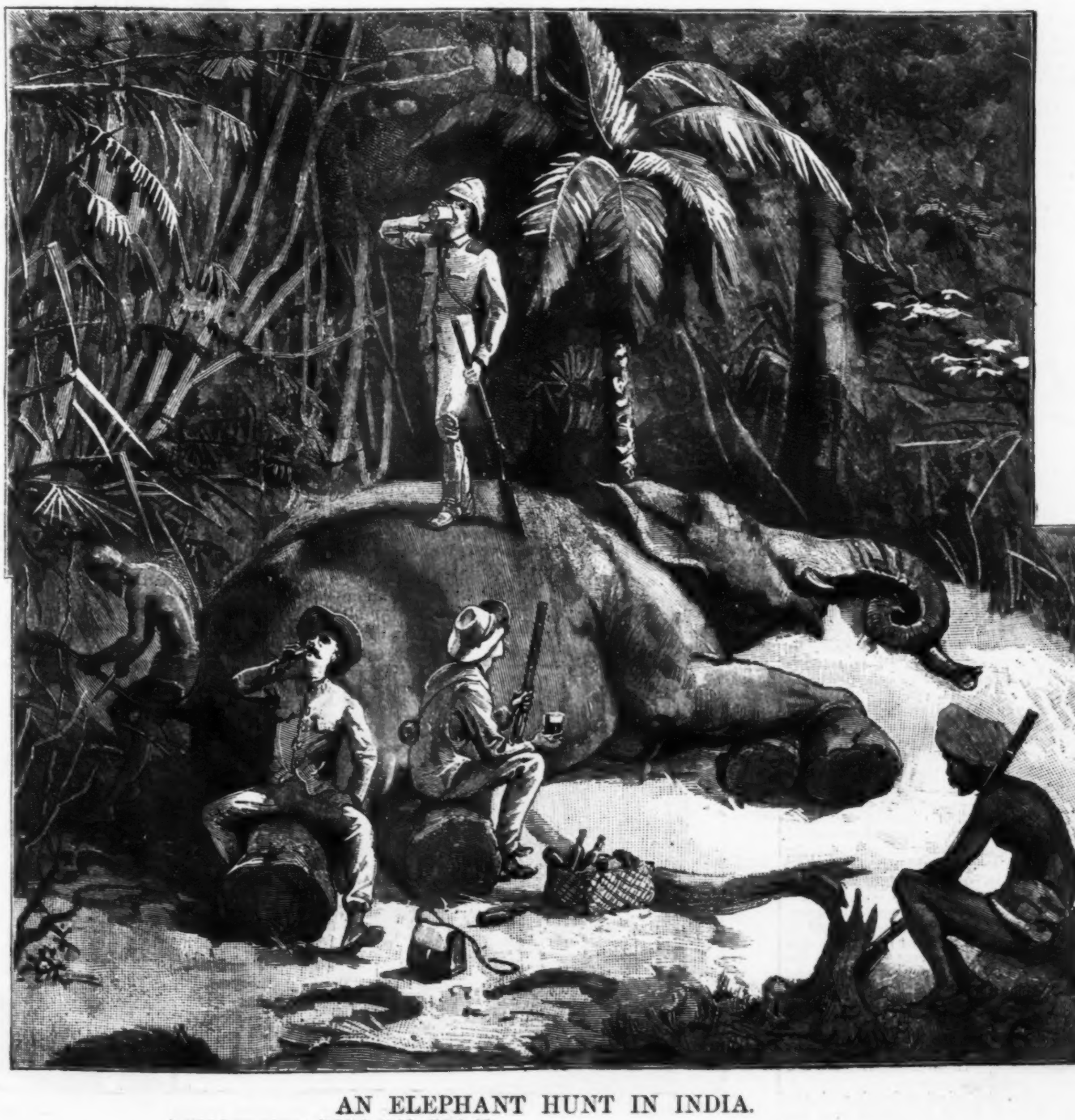
On the return jouney it was decided, in order to obtain a short cut, to cross a river teeming with crocodiles, and for this purpose a raft was constructed, which was towed by the Kanda Kadu ferryman, who boldly plunged into the water and swam across with the guns and ammunition, then returning for the human members of the party. To "J. M.," as being the oldest *shikaar* (sportsman) in the island, the seat of honor in the raft was given, and the two others helped the ferryman to take their passenger across. All the way they shouted and yelled "Thu! Thu!" to keep off the crocodiles, and were by no means sorry when dry land was reached. They got to the camp in the afternoon without further adventure, and cracked a bottle of "fizz" to celebrate the death of the "rogue," much to the satisfaction of their numerous native friends who had assembled outside the tent.—*London Graphic.*

CURIOUS INVENTIONS.

OPTICAL ILLUSIONS.

SPECTRAL illusions date back nearly a century. Descriptions of them are found in the memoirs of the physicist Etienne Gaspard Robertson (1762 to 1837), who invented phantasmagorias by projection. This mode of illusion was completely transformed by Robin, who conceived the idea of obtaining the real image of a living person by means of a transparent glass invisible to the spectator. Robin's representations created great excitement at Paris some twenty-five years ago, and our contributor, Mr. G. Kerlus, has already given a thorough description of them in this journal. His article terminated with a short description of dissolving specters, which we shall reproduce, since it contains the principle of those metempsychoses that for two or three years have been obtaining a certain measure of success on some stages of the capital and in strolling exhibitions. The following is the description:

"Dissolving specters consist in the successive and uninterrupted appearance of various objects that are transformed before the spectators' eyes. In this way, Mr. Robert Houdin obtained very curious effects. Dissolving specters are obtained by placing an object on the stage so as to be seen directly, and another beneath so as to be seen by reflection, and by gradually illuminating one and not the other. The image the least illuminated disappears and gives place at the same point to that of the object which at this moment is receiving the entire light. . . .



AN ELEPHANT HUNT IN INDIA.

"When the theater, through its arrangement, does not allow the actor forming the specter to be placed beneath the stage, he may stand behind the scenes. In this case, the glass must be vertical, but diagonal on the stage."

Now for the trick of metempsychosis. Fig. 1 gives a general idea of the appearance of the stage at the moment the doors of the transformation temple are opened.

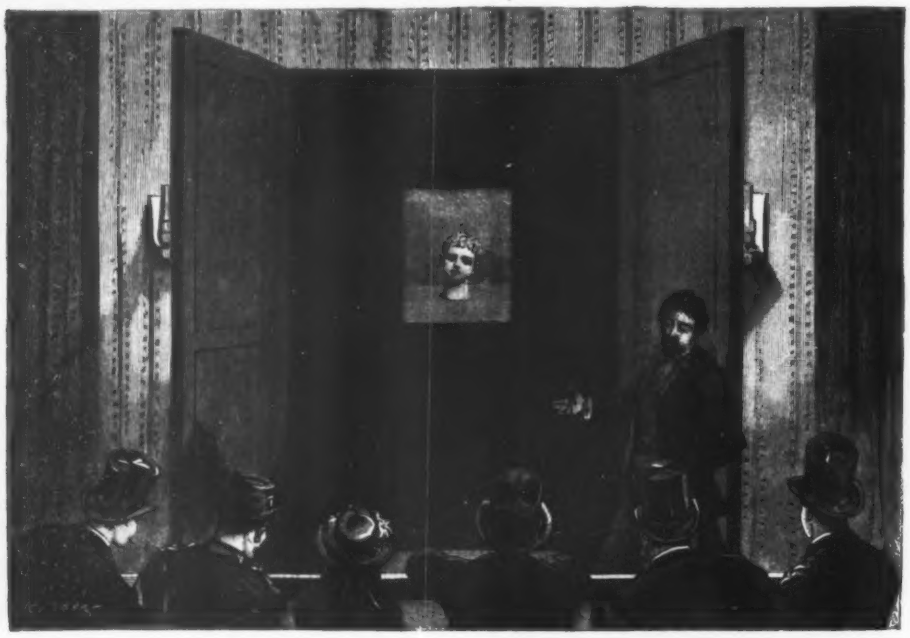


FIG. 1.—AN OPTICAL ILLUSION.

At the back of a deep and slightly conical aperture, entirely lined with black, appears under a strong light, in the center of a cubical cavity about 24 inches square, a plaster or paper pulp head that the showman picks up and passes around among the spectators in order to well show the materiality of its existence. After it has been examined, the head is put back in place, when, gradually, it becomes animate.

The eyelids wink, the face takes on a color, the mouth smiles, and, in less than a minute, the plaster head has entirely disappeared and given place to the head of a live woman which moves its eyes. Then, by an opposite effect, the living head becomes pallid and changes into plaster again. This plaster head afterward becomes a death's head from which a bouquet of artificial flowers appears to make its exit. Then the death's head disappears, and is replaced by a pot, which supports the bouquet. The showman then approaches the stage and takes the bouquet, and passes it around among the spectators. After putting it back in place, he makes it disappear and shows in place of it a globe of gold fish from which he afterward causes

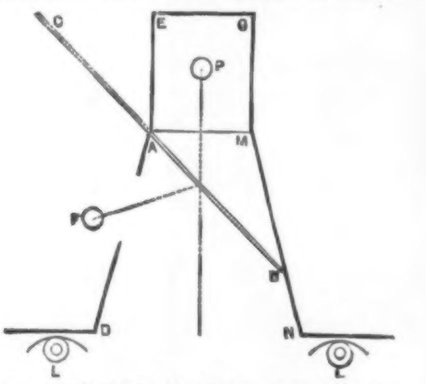


FIG. 2.—DIAGRAM EXPLANATORY OF THE TRICK.

the plaster head to emerge. This latter apparition terminates an exhibition which, through successive transformations, might thus be continued indefinitely.

The reader has already guessed that, in these transformations, the objects that succeed one another are seen alternately, directly, and by reflection. The diagram in Fig. 2 shows the principle of the very simple arrangement that permits these results to be obtained. At P is the real object lying upon a shelf, EGAM. At AB is a plate of glass inclined at an angle of about 45°. As the object, P, is directly and brilliantly illuminated, it alone is seen; but if a second object be placed at F, and be gradually illuminated, its image, reflected by the glass, AB, will appear to the spectators to be at P, that is to say, the plaster head will be replaced by the head of the living woman, F.

It would seem as if the glass would prevent the showman from approaching to take up the plaster head to show it to the spectators; but it does not, since the glass has not necessarily the dimensions shown in the diagram, its lower edge stopping nearly on a level with the shelf upon which the head, P, lies. In the case of a stage and of objects of very large size, it would not be difficult to slide the glass back to AC, when the showman approaches to take up one of the objects placed at P. The darkness of the place in which the glass is situated would prevent the shifting from being seen.

The manner of placing the plaster head and the bouquet, moreover, allow it to be supposed that the objects are simply passed under the glass, which consequently remains immovable.

In fine, the plaster head is seen directly through the glass, AB, and the woman's head that replaces it is seen by reflection; the former returns and there is substituted for the living head a death's head, which, illuminated in turn, shows its reflected image at the spot where the plaster head was. As the latter is no longer illuminated, it ceases to be visible. Nothing is easier then than to remove the plaster head and substitute a bouquet for it without the maneuver being seen by the spectators, as the bouquet does not become visible until it is directly illuminated.

We have easily performed all these experiments with a model of small size formed of a simple cardboard box 10 inches in section and 24 inches in length. To complete the apparatus it sufficed to fix an ordinary pane of glass at an angle of 45°.

The inside of the box was lined with black paper, and apertures were made in the side for illuminating the objects through two incandescent lamps, maneuvered by rheostats, in order to vary the light and effect the necessary substitutions.

The experiments that succeed best with such an apparatus consist in making a fruit ripen, and in exhibiting a blond doll's head and then converting it into a brunette. A skillful box maker might certainly utilize this experiment, and make an interesting and cheap toy, since the use of incandescent lamps is in nowise obligatory.

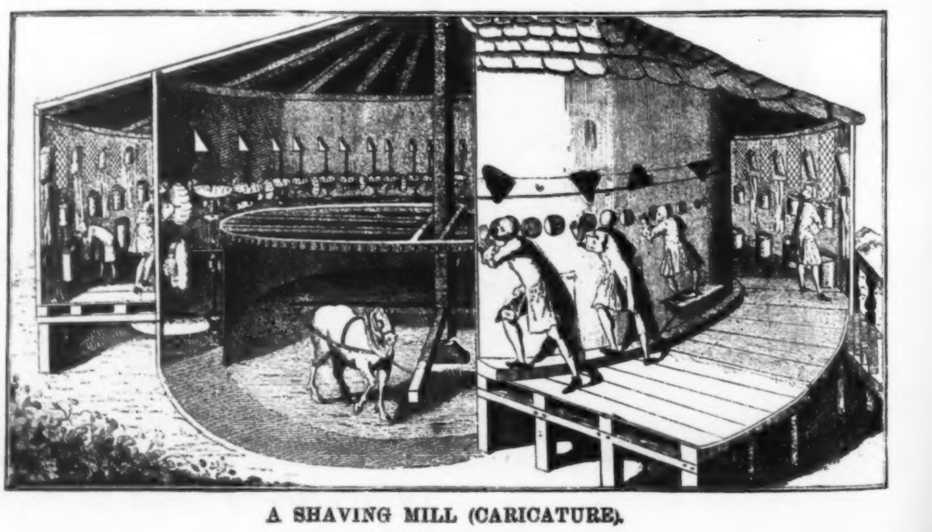
In strolling shows the installation is completed by a few artifices that contribute to increase the delusion. Thus, lamps placed at L serve to illuminate the spectators, and even to dazzle their eyes a little, so as to make the background appear darker; and the plaster head is moulded from that of the person who animates it. All these details make an attractive and interesting spectacle of the metempsychoses, and one which, although not very novel in principle, is at least skilfully presented and merits the same success as Robin's specters, from which it is derived.

AN EIGHTEENTH CENTURY CARICATURE.

It is sometimes imagined that, before the reign of steam, machines were not very numerous and did not occupy people's attention much. The multiple mechanisms that we meet with everywhere at present certainly did not formerly exist, but machines of all kinds, and even those designed for the uses of domestic life, were not wanting. As an evidence of this, let us take the accompanying caricature, which derides the manufacturers of domestic apparatus. It represents a shaving mill with which it is possible to shave and dress the hair of sixty persons a minute. The original engraving is three times the size of our reproduction, and is very rare. It appears to us to belong to the beginning of the reign of Louis XVI.

The caricature speaks for itself, and needs no explanation. We shall not reproduce the long title that accompanies the original, but shall be content to add that the inventor announces that he is preparing a new machine to make wigs.

It will be seen that the machine is set in motion by a horse harnessed to a whim. Scarcely any motors were known at the time except animate ones, and the artist could not imagine any other.



A SHAVING MILL (CARICATURE).

MAGIC COINS.

The street venders of Paris have for some time past been selling to pedestrians a coin that can be made to enter an ordinary wine bottle. This coin is a genuine ten centime piece, but, when it is handled, it is found that it bends exactly like the leaves of a dining room table. Amateur mechanics, clockmakers, and copper turners can easily manufacture similar ones. The process is as follows:

By means of a very fine metal saw, cut the coin in three pieces, either by parallel cuts, or, better, by following the contours shown in Fig. 1. If the operation be skillfully performed, the marks of the cutting tool will be nearly invisible. Before the coin is sawed, a groove about a line in depth should be formed in the rim by means of a saw or file. In this channel or groove is inserted a very taut rubber ring, which, before it is stretched, should be, at the most, one and a half or two lines in diameter. If the rubber is well hidden in the groove, the cleft coin will appear to be absolutely intact.

Owing to this process, the coin can be easily inserted in a bottle by placing the hands as shown in Fig. 2.

FIG. 1.—MAGIC COINS.

FIG. 2.—MODE OF INSERTING THE COIN IN A BOTTLE.

FIG. 3.—THE DOUBLE SOU.

The hand that bends the coin covers the mouth. The coin is inserted, and then, by a smart blow given the bottle, it is made to pass through the neck. Owing to the tension of the rubber, the piece at once regains its flat form, and the operator makes it ring against the glass in order to show that it is really a piece of metal. In order to extract it, it is necessary to get the saw marks exactly in the direction of the bottle's axis, then the bottle is slightly inclined, neck downward, and through a few blows on the latter the coin is made to drop into the hand, where it will at once assume its original form.

We shall now have a few words to say about what is called the "double sou." The operator places the prepared coin in his hand, and calls strict attention to the fact that there is no companion piece. Then he covers it with his other hand for a moment, and finally shows two coins, instead of one, in the first hand.

Fig. 3 shows, not how the experiment is performed, but how the double coin is prepared. It is simply an ordinary sou, over which is placed a sort of hollow cover containing the impression of the coin, and which fits on the latter so accurately that the piece looks like an ordinary sou. This cover is lifted and made to slide alongside of the coin, thus showing two pieces instead of one.

The cover is stamped from a thin sheet of copper placed upon a sou serving as a mould. It might possibly be made by means of some electro-metallurgic process.—*La Nature*.

TO PREVENT ROLLING OF VESSELS.

THE Detroit Dry Dock Co. have lately built a ferry steamer which is designed to cross the straits of Mackinac all winter, in connection with the Michigan Central, and will have to work her way through very thick

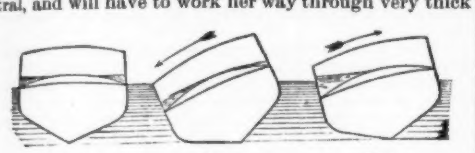


FIG. 1. FIG. 2. FIG. 3.

ice. She has two propellers, one forward and one aft, and the forward propeller is expected to dislodge the ice, while the engines working the after propeller, being more powerful, will continue to shove her ahead. She is built with considerable rise of floor, which, it is claimed, will assist her to break the ice. The forward propeller is 10 ft. diameter, and the after propeller 12 ft. She carries ten cars, and is built very strongly of oak, with metal sheathing. The forward engine is designed to indicate 1,000 h. p. and the after engine 2,000. She has three boilers of the Scotch type, measuring each 18 ft. by 11 ft. 6 in. She has double smokestacks.

She is also provided with what is the only known effective device for diminishing rolling, which has as yet been only used in a few British ironclads, but it has been tried on one of the Inman Atlantic steamers. This consists of rolling tanks, which extend right across the ship and are partially filled with water, each tank holding about thirty tons of water. The floor of the tank is curved, being highest in the center of the ship. As the ship rolls, the water, of course, all runs to the lower side of the tank, which becomes full just as the ship has reached her lowest point and is rolling back again.

In the accompanying diagram, Fig. 1 represents the tank when the vessel is on an even keel in still water. Fig. 2 shows the vessel at her extreme angle of roll, and shows the water in the tank following the movement of the ship. Fig. 3 shows the vessel recovering from her roll, while the water has all run to the lowest side of the ship, which is now rising as shown by the arrow heads.

The weight of water is then against her rolling back again, because it is on the side of the ship which tends to rise. When that side has risen, the water runs to what is now the lowest side, but by the time the water gets there that side of the ship is rising, and hence the weight of the water is always on the side of the ship which is rising, and therefore her rolling is checked. The principle of this device is that, owing to the curve in the bottom of the tank, the ship rolls quicker than the water can run from side to side. In some experiments tried on one of the Inman steamers, a roll of seventeen degrees, which is very uncomfortable, was diminished to three degrees, which is hardly perceptible. This device will, it is stated, be applied to the new large steamers for the Inman line now building, and will add another no inconsiderable improvement to an Atlantic voyage.—*Railroad Gazette*.

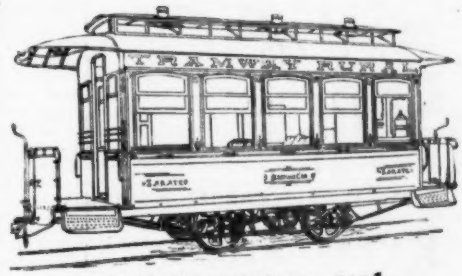
OIL FURNACES AT THE FORTH BRIDGE WORKS.

By E. W. MOIR.

THE ordinary methods for heating rivets were found to be quite inadequate to supply, at a moderate cost, the great numbers required for the special riveting plant of the Forth bridge works. In the construction of the cylindrical columns, rivets of various lengths had to be heated in a confined space, at the rate of three or four per minute. To supply the want, Mr. Arrol designed several different oil furnaces and burners, of which the drawings shown below represent the latest and most approved pattern. The oil used is that which is condensed from waste gases produced in blast furnaces, and although the price of it has greatly increased since the introduction of the lucigen lamp, it is a cheaper fuel than coal for rivet heating. Fig. 3 is a general front elevation of the furnace, burner, and oil tank; Figs. 1 and 2 being respectively a longitudinal and a cross section of the furnace of latest design. It is a small fire clay lined iron box, made of ¼ inch plates and angle framing, having one end round in plan, viz., that at which the oil jet enters. The rivets to be heated lie on the floor of the furnace, upon which they are placed through four sliding doors. The crown of the arched roof is built 2 in. below the top plate, thus leaving a passage along which the air used in combustion is made to pass before meeting with the jet of oil, receiving in its passage a certain amount of heat. The amount of air passing along this passage is controlled by two small doors, one at the back and one in front of the furnace. The oil tank is cylindrical in form, and made of galvanized iron, being large enough to hold fifteen gallons—a quantity sufficient to keep the furnace working four and a half hours. In the center of the domed top of this tank there is fixed a cross piece, having one 1 inch and three ½ inch branches. The inch branch is made fast to the top of the tank, and has passed down through it a ½ inch pipe, which reaches to within an inch of the bottom (see Fig. 3). Air at 20 lb. per square inch is conveyed through the flexible hose, H, Fig. 3, to one of the two horizontal arms of the cross pieces, its admission being controlled by a small brass plug cock. The air pressing on the surface of the oil forces it up the central pipe already mentioned, from whence it is carried by the flexible hose, H_1, to the branch, B, on the side of the burner (see Fig. 4). The second horizontal branch of the cross piece is connected by the flexible hose, H_2, through which the air passes to the end, D, of the burner (Fig. 4). The burner, as can be seen from the sectional elevation, is something like an injector; the central pointed nozzle through which the air passes is moved longitudinally by means of a butterfly nut, A, regulating by its motion the quantity of oil passed into the furnace, which, as already stated, is forced by the air through the branch, B, into the annular space round the nozzle. The quantity of air passing through the burner is controlled by the cock, C. To light the furnace when it is all connected as described, the air is turned on at the cock, H, Fig. 3, which controls the supply, and the oil is forced into the burner through the branch, B. The nozzle is then drawn back by the butterfly nut the necessary amount, and the air passing up its center disintegrates the oil into a fine spray, when it can be ignited by a match or lighted piece of waste. The air which passes through the nozzle is not nearly sufficient for combustion, the remainder being drawn along the upper heated passage in the furnace already described, and coming down through the holes in the arched roof meets the spray just as it enters. As already mentioned, the furnace is less costly than a coal one large enough to do the same work, and it has the additional advantage of being about one-sixth the weight. Furnaces of this class are being used at the Forth bridge works for heating the ends of angles to be joggled or cut, for which work they are superior to an ordinary smithy fire.—*Industries*.

STREET RAILWAY SLEEPING CAR.

THE longest street railway line is in South America, in the Argentine Republic, running east and west of Buenos Ayres, and connecting that city with a number of outlying towns. The length of the line is about 250 miles, and its route is along the course of the Rio Parana to Zarate. The grades are very light. Horse traction is employed for the reason that while coal costs about 11 dols. per ton, a good horse can be purchased for 20 dols., while another 20 dols. will nearly cover the expense of keeping him for a year. The horses are changed frequently during the trip. The entire trip occupies about three days, and the fare is 50 dols. The road is owned by a company headed by a resident of Buenos Ayres, and it is understood to have been equipped by English capital.



TRAMWAY SLEEPING CAR.

The sleeping cars are 18 ft. long over the body, and 8 ft. wide. They have four upper and four lower berths, adapted for one occupant each, although two slim persons could sleep in them with comfort. The arrangement of the berths, and the general interior arrangement of the car, is similar to that adopted for railroad sleeping cars in the United States. The interior is handsomely finished in carved mahogany and upholstered with fine plush cushions; the faces of the upper berths are paneled and decorated with inlaid woodwork. During the day, tables for lunch, cards, etc., can be placed between the seats, and are set in a little closet at one end when not in use. A passageway of convenient width runs longitudinally between the seats.

At one end of the car is a water closet, with hopper and urinal. A very small stove is provided, and is placed in a fireproof alcove extending into the water closet. The car is provided with a toilet room, fitted with a marble top wash basin, nickel-plated pump, and a large tank underneath the wash stand; the toilet room has also a linen closet, a closet for a blacking box, etc., and a water cooler. The car is lighted at night with three center lamps. The deck lights have small squares of moulded and tinted glass, and the sashes below are glazed with polished plate glass. A Brussels carpet covers the whole floor of the sleeping compartment, which is separated from the toilet room, or saloon, by a double hinged door.

INTERIOR OF TRAMWAY SLEEPING CAR.

In the interior view, the right hand side of the car is shown as arranged for the daytime, with the seats and tables in place and the upper berths shut up against the roof; while on the left hand side the berths are let down, the curtains rigged, and the beds made up for the night. The cars were boxed whole for shipping, except that the sub-sills, running gear, and platforms were taken off and shipped in separate packages.

The cars were built last year, by the J. G. Brill Company, of Philadelphia, Pa., who have also sent out a large amount of other equipment, including passenger, freight, and refrigerator cars, two derrick cars, and some hearse cars for funeral trains.

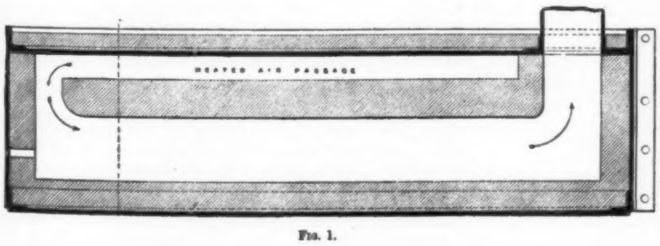


FIG. 1.

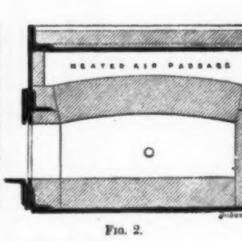


FIG. 2.

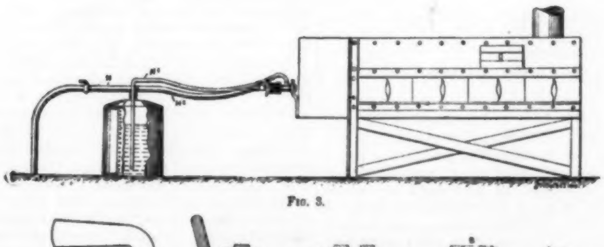


FIG. 3.

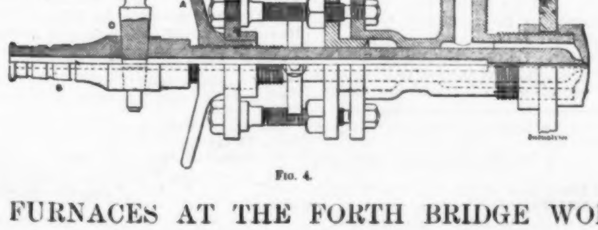


FIG. 4.

OIL FURNACES AT THE FORTH BRIDGE WORKS.

[Continued from SUPPLEMENT, No. 629, page 10044.]

THE DEVELOPMENT OF THE MERCURIAL AIR PUMP.*

By Professor SILVANUS P. THOMPSON, D.Sc., B.A.

IN 1873, Mitscherlich† altered the pump in the manner shown in Fig. 13. The double function performed by the three-way tap was in this form shared between an automatic valve, V, opening upward only, and a plain glass tap, T, worked by hand. The valve con-

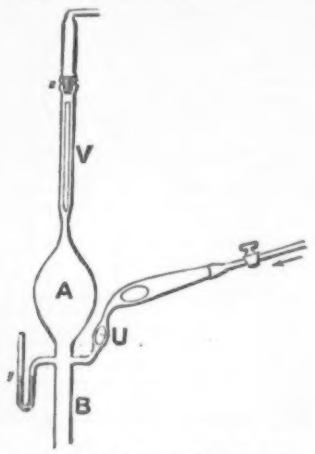


FIG. 13.—MITSCHERLICH'S PUMP.

sisted of a rod of glass, ground conical at its lower end, fitting into a tube of one centimeter internal diameter. This rod was raised from its seat by the mercury as it rose through the pump head. A perforated cork placed in the eject tube above the valve prevented it from rising too high, otherwise it would, in falling, become jammed. The exhaust tube communicated with the pump through the tap, T, at a point below the pump head; the communicating tube being enlarged to receive anhydrous phosphoric acid or other drying materials, the same being protected from the rising of the mercury by the interposition of a loosely fitting glass valve of ovate shape, U.

Another modification, due to Lane-Fox,‡ is shown in Fig. 14. The valve at the top of the pump head is a

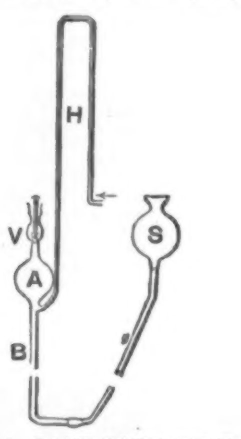


FIG. 14.—LANE-FOX'S PUMP.

conical glass stopper ground to fit tightly into its seat, requiring to be removed and replaced by hand. The overhead tube, H, which acts as a barometric trap, is joined to the shaft of the pump just below the pump head. Lane-Fox also suggested the use of an automatic valve (like that of Alvergniat) to obviate the necessity of using the tall head tube. This pump was for a long time used by the Anglo-American Brush Electric Light corporation for exhausting the Lane-Fox incandescence lamps. They introduced a number of modifications in detail, one of which consisted in replacing the stopper, V, by an automatic valve resembling Mitscherlich's. A side tube leads from below the lower automatic valve, U, to the tap of the pump head. There is also a spark gauge. A drawing of one of the intermediate forms of Lane-Fox pump is given in Gordon's "Electric Lighting" (1884), p. 83.

About the same date, minor improvements were suggested by several persons. Mr. Dew Smith of Cambridge suggested the use, at the top of the pump head, of an automatic valve consisting of a strip of rubber or silk stretched over an orifice, precisely as in many mechanical air pumps, the valve itself being surrounded by an upper mercury cup to insure a tight joint. Messrs. Goebel and Kulenkamp,§ who used an automatic glass valve to close the top of the pump head, adopted above it a flexible tube, by means of which to return to the supply vessel the small quantities of mercury which from time to time were driven up through the pump head with the ejected air. Guglielmo,‖ applying a very similar device, achieved the not unimportant result of causing the tap at the top of the pump head to discharge the ejected residual air into a space already partially exhausted. This he accomplished by interposing in the flexible tube connecting the summit of the pump head with the closed top of the supply vessel a vertical glass tube, about 20 centimeters long, with a three-way tap opening also into the air. Through this tap atmospheric pressure could be momentarily established when the supply vessel was in its lower position, and nearly full of mercury. When it was raised, the mercury ran out of it into the pump head, leaving the space in it partially exhausted, and into this vacuous space the three-way tap at the top of pump head opened to let out the ejected air. As will be seen later on, this device makes this pump resemble somewhat some pumps of the third group.

Mr. Albert Geissler* has replaced the three-way tap by two automatic valves (Fig. 15), one of which, V, opens from the top of the pump head into the outer air,

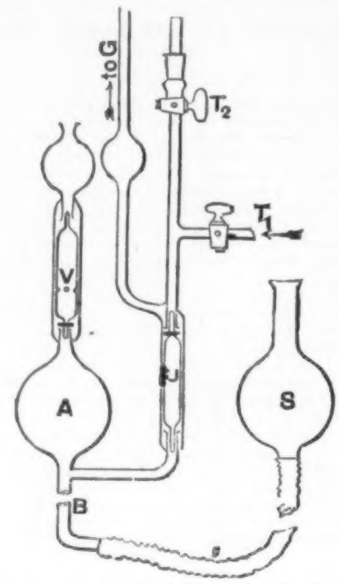


FIG. 15.—ALBERT GEISSLER'S PUMP.

the other, U, admits air from the vessel to be exhausted into the pump just below the pump head, as in the Mitscherlich and Lane-Fox pumps. These valves are hollow tubes of glass, with spindle ends to guide their motion, which float in the mercury when it reaches them. They are provided with accurately ground glass collars instead of conical ends, to fit against the ends of the tubes which they respectively close. An additional tap, T, is interposed for safety between the pump and the vessel to be exhausted. Other tubes lead to the manometric gauge and to the drying apparatus. This form of pump is intended for industrial use, where power is available to keep the supply vessel slowly rising and sinking. A small improvement of recent date, due to Messrs. Greisser and Friedrichs,† consists of a new three-way tap of peculiar construction, pierced with two transverse channels at 45°. Of the three openings, two are at one side of the barrel, one at the other, so that the top has to be worked through 180° instead of 90°, and the channels in the grease do not lead directly from one aperture to another. Hence there is a lesser risk of leakage.

In 1881, Mr. Rankin Kennedy‡ prepared a pump for exhausting lamps, going back in principle to that of Baader. Mercury is passed down a supply tube, S (Fig. 16), and rises with the pump head, expelling the

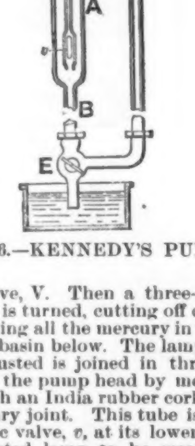


FIG. 16.—KENNEDY'S PUMP.

air through a valve, V. Then a three-way eject tap, E, at the bottom, is turned, cutting off communication with S, and allowing all the mercury in the pump head to run out into a basin below. The lamp, or other vessel, R, to be exhausted is joined in through an aperture at the top of the pump head by means of a tube passing in through an India rubber cork, c, and sealed above by a mercury joint. This tube is also supplied with an automatic valve, v, at its lower end, to allow it and the exhausted lamp to be removed from the pump, in order to seal it off. A similar device has also been described by Akester. Akester's pump§ closely resembled that of Lane-Fox, but in it the raising and lowering of the supply vessel was obviated by using, at the bottom of the pump shaft, a three-way tap, enabling the barometric column to be placed alternately in communication with a supply cistern placed at a high level and with a return pipe through which the descending mercury flowed away at a lower level, to be again pumped up to the high level by a mechanical pump. Another way of raising and lowering the mercury in the pump, which also dispensed with flexible tubing, was suggested by Rock.* (A similar device was suggested by Mile in 1830.) The pump head and barometric column are formed by a single straight cylindrical tube, about 100 centimeters long, 10 centimeters in internal diameter of glass, and 1 centimeter in thickness. It is open at the bottom, but closed in and furnished with the usual three-way tap at the top. Outside it is a second, slightly longer tube, having an internal diameter of 12·6 centimeters. This—the supply vessel—is closed at the bottom, and can be raised or lowered mechanically. If the outer one, filled with quicksilver, is raised, the liquid forces its way up the inner tube, driving the air before it, through the three-way tap. When it is lowered, the mercury remains inside, to a height which will never exceed 76 centimeters above the level of the mercury in the outer tube, the space above being left vacuous. The inventor claims that this construction is less liable to give trouble than the usual form. Cruto† has used a somewhat similar device, but with sulphuric acid instead of mercury in the pump. To obviate having to work with a pump shaft twenty feet long, he adopted the device of an auxiliary exhaust pump. Narr‡ has described a simple pump on Jolly's plan, but having steel taps, the pump head of glass being united above and below to the working parts by carefully ground and lightly greased steel unions, clamped together by screws. By reason of its strength, this construction seems to be preferable in cases where very high vacua are not required.

Double action pumps have been suggested by various persons. Kemp's pump (Fig. 8) was of this class, so is one by Serravalle,§ in which there are two supply vessels, so arranged that while one rises the other descends; two separate pump heads, with two three-way taps automatically opened and shut, and two exhaust tubes uniting into one. Another double pump, by Gardiner,‖ depicted in Fig. 17, is worked mechanically

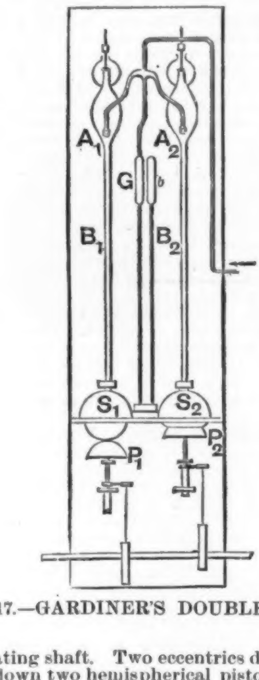


FIG. 17.—GARDINER'S DOUBLE PUMP.

from a rotating shaft. Two eccentrics drive alternately up and down two hemispherical pistons, P_1 and P_2, which press in the flexible hemispherical bottoms of the two supply vessels. The valves of this pump are all automatic, as in Kemp's pump. It is provided with a barometric gauge, G, and a comparison barometer, b.

SUB-CLASS Ia.—SHORTENED UPWARD-DRIVING PUMPS.

The length of the pump shaft in the preceding cases being necessarily equal to that of the barometric column renders all these forms of apparatus more or less unwieldy. Although a column of mercury 76 centimeters high is a necessity for working between vacuum within and atmospheric pressure without, no such length is required when working between vacuum and a reduced pressure. In fact, the length of the pump may be shortened by reducing the pressure of the air above the surface of the mercury in the supply vessel, in all pumps of class I. and class II. The first suggestion for shortening the pump came from the Rev. Professor Robinson,¶ in 1864, and was almost immediately followed by one from Professor Poggendorff.** In these apparatus a common air pump worked by hand was used to produce a partial vacuum. The pump shaft was quite short, and ended in an auxiliary chamber, closed at the top, but having a tap communicating either with the auxiliary pump or with the outer air. The three-way tap above the pump head also opened into a tube which could be made to communicate either with the auxiliary pump or with the outer air. To fill the pump head with mercury, air was admitted to the auxiliary chamber, while at the same time the auxiliary pump was applied at the top to suck the mercury into the pump head. The three-

* Lecture before the Society of Arts, London, November, 1887. From the *Journal* of the Society.

† Mitscherlich. "Pogg. Ann.," cl., 420, 1873.

‡ Lane-Fox. Patent Specification 3,494 of 1880.

§ "Wied. Beiblatter," vi., 849. 1882. See also specification of patent 5,548 of 1881.

‖ Guglielmo. "Weid. Beibl.," viii., 739, 1884.

* A. Geissler. "Centralzeitung fur Optik und Mechanik," vii., 12, 1886; also D. R. patent, No. 32,224, 1885.

† Greisser and Friedrichs. See "La Lumiere Electrique," xxiii., 335, 1887.

‡ Kennedy. Specification of patent 5,524 of 1881. See also Dredge's "Electric Illumination," ii., p. ccxxxii.

§ Akester. See specifications of patents 4,458 of 1881 and 2,519 of 1882.

* Rock. "Wied. Beibl.," vii., 790, 1883.

† Cruto. Specification of patent 1,895 of 1882.

‡ Narr. Ueber eine Abanderung der Jolly'schen Quecksilberluftpumpe. "Wied. Annalen," 542, 1885.

§ Serravalle. "Riv. Scient. Industr.," xiv., 401, 1882; also "Wied. Beibl.," vii., 490, 1883.

‖ Gardiner. See "La Lumiere Electrique," xiii., 219, 1884.

¶ T. R. Robinson. "Description of a New Mercurial Gasometer and Air Pump." "Proc. Roy. Soc.," xiii., 321, 1864. *Phil. Mag.*, xxviii., 235, Sept., 1864.

** Poggendorff. "Pogg. Ann.," cxxv., 151, 1865. See also Muller-Poullet's "Physik" (1876), i., 233.

way tap being then turned to put the pump head into the vessel to be exhausted, the auxiliary pump was used to reduce the pressure in the auxiliary chamber, causing the mercury in the pump head to fall, the height of the column representing always the difference between the pressure in the pump head and that in the chamber.

Several later experimenters have adopted this device of applying an auxiliary pump to shorten the vacuum pump, and, as we shall see, the device is applicable to each of the three main classes of pumps. Dr. F. Neesen,* whose more recent pump is described later, adopted this device in 1878. At that date he was employing a shortened Geissler pump, to which, independently of Mitscherlich, he had applied an automatic exit valve above the pump head. He had also introduced another notable improvement, namely, a side tube, connecting the exhaust tube from a point a little beyond where it branched off from the pump shaft to a point above the pump head, below the automatic valve. Such a side tube, marked N in Figs. 18 and 33, prevents the fracture of the top of the pump head by air bubbles suddenly rising through the mercury in the barometric column.

Schuller,† in 1881, described another shortened pump, with numerous carefully considered details, and a curious automatic method of operating, which, however, need not here be described. Fig. 18 shows Schuller's

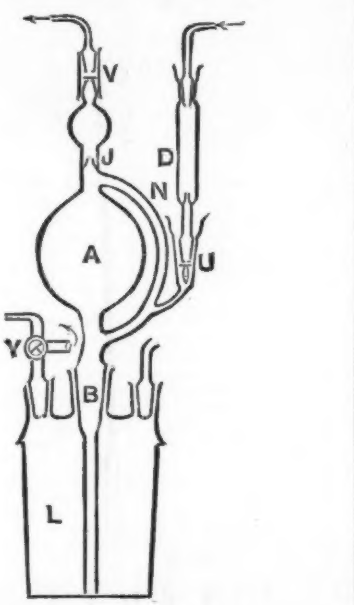


FIG. 18.—SCHULLER'S PUMP.

pump. V and U are automatic valves consisting of small pieces of flat glass, preferably triangular, which close the mouths of tubes that have been also carefully ground flat. In the valve, V, shown in detail in Fig. 19, the weight of the small glass plate is partly sustained by the ring of mercury surrounding the tube end above which it lies.

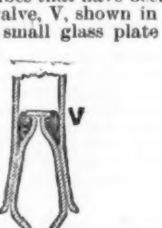


FIG. 19.—DETAIL OF VALVE.

Another feature of Schuller's pump is the valve, J, situated in the tube between the pump head and the upper valve, V. This valve, J, shown larger in Fig. 20, is composed wholly of mercury, which, during the descent of the body of liquid down the tube, forms, by virtue of its great surface tension, a cap over the orifice three millimeters in diameter, which is here interposed. As in Geissler's later pumps, there is an auxiliary chamber, M, between V and J, in which a partial vacuum is formed, so that the residual air expelled from the pump head is driven into an already exhausted space. The little vault of mercury over the aperture in J is able to withstand the difference of pressure between the partial vacuum above and the nearly perfect vacuum below it. At the commencement, a partial vacuum is made in the pump head, through the upper valve, by an auxiliary mechanical pump. A three-way tap, Y, suffices to put the space in the bottle, L, alternately into communication with the atmospheric air and with a tube leading to an auxiliary mechanical air pump.

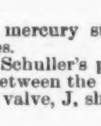


FIG. 20.—SCHULLER'S MERCURY VALVE.

* Neesen. "Wied. Ann.," iii., 608, 1878; also "Zeitschrift fur Instrumentenkunde," ii., 287, 1882.

† Alois Schuller. "Wied. Ann.," iii., 328, 1881.

Another pump of this class, by Dittmar,* has simply two plain glass taps, one above, the other in the exhaust tube at the side of the pump head. It obviously could not give a good vacuum.

The most recent pump in this category appears to be that of M. A. Joannis.† The ordinary three-way tap at the top of the pump head communicates with the open air. Below, at the lower end of the pump shaft, is a closed vessel, communicating by another three-way tap with a water aspirator and with a source of pressure by means of which the mercury is alternately raised and lowered.

CLASS II.—DOWNWARD-DRIVING PUMPS.

The idea of expelling the residual air down a barometric column originated with Dr. Hermann Sprengel,‡ who in the year 1865 brought out the pump which is associated with his name. He had in the preceding years been studying the uses in the laboratory of the water trombe or aspirator, a much older instrument, used for some hundreds of years for delivering air under pressure. The theory of this ancient apparatus had already received the attention of Magnus § and of Buff,‖ and Sprengel ¶ had himself devoted some attention to this method of furnishing air for the blowpipe. It appears to have been an original idea with him to substitute falling mercury in the place of falling water, in order to extract gases by means of the vacuum produced above the column.

The form of the original Sprengel pump is shown in Figs. 21 and 22. The supply vessel, S, was, in this case,

FIG. 21.—SPRENGEL'S PUMP (SIMPLE FORM).

a funnel fixed at the top of the apparatus, from which the mercury was delivered at a steady rate through a narrow India rubber tube, nipped by an adjustable pinch cock. After passing this point it fell in drops down a glass tube, F, of narrow bore, but having strong external walls, and known as the fall tube. As it fell down this tube in drops, it swept out the air of the tube and the air which entered from the side, each drop acting as a piston to propel the air below it. To secure this action, it is essential that the fall tube should not be too wide. For rapid, partial exhaustions, an internal bore of 2 to 3 millimeters appears to be about the best size. For slower exhaustions, carried to the highest degree of rarefaction, a bore of 1·4 to 1·8 millimeters appears to be preferable.** During the first stages of the process of exhaustion, while yet there is a considerable amount of air in the fall tube, the successive drops of mercury move separately down the tube, almost silently, being separated from one another by the intervening cushions of air, which, as they descend the tube, become more and more compressed. As a higher degree of rarefaction is attained there is no longer a sufficient cushion of air, the drops fall smartly through the vacuous space with a loud metallic clinking sound as they strike upon the top of the barometric column, which occupies the lower thirty inches or so of the fall tube. At the bottom of the fall tube the air and mercury enter a suitable vessel, K, from which,

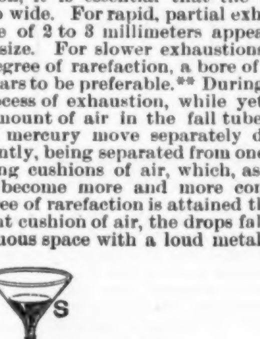


FIG. 22.—SPRENGEL'S PUMP (SECOND FORM).

* Dittmar. See "Challenger Report: Physics and Chemistry," vol. i., 1884. Plate 3.

† Joannis. Modification de la machine pneumatique a mercure. "Ann. Chim. Phys." Series vi., xi., 285, 1887.

‡ Sprengel. "Journ. Chemical Soc.," Series II., iii., 9, 1865. See also "Pogg. Ann.," cxxix., 564, 1865.

§ Magnus. "Pogg. Ann.," lxxx., p. 32, 1850.

‖ Buff. "Ann. der Chem. und Pharm.," lxxix., 249, 1851.

¶ Sprengel. "Pogg. Ann.," cxii., 634, 1861.

** See Gimingham. "Journ. Soc. Chem. Industry," iii., 84, 1884.

if desired, the air that has been carried down the fall tube may be collected. The mercury which flows into K must be periodically collected and poured again into the supply funnel at the top. In the second form (Fig. 22), a downward bend is inserted between the supply funnel and the point where the mercury begins to break away into drops. This bend leads to a small chamber, virtually the pump head, from the end of which the mercury falls in drops. The flow is regulated by a pinch cock, r, which can be screwed up to nip, more or less tightly, a piece of flexible India rubber tubing inserted in the supply tube. In this figure there is also shown a small mechanical air pump for rapidly producing the first partial exhaustion, and barometric gauge, b, to show the degree of rarefaction attained.

The introduction of the Sprengel form of pump at once attracted a revived attention to the advantages of mercurial pumps for exhausting, and it was soon in the hands of many experimenters. Graham* applied it to extract minute quantities of gases in his researches on gaseous diffusion. Bunsen† adapted it for the purpose of hastening filtration, employing a form somewhat modified to admit of the use of drops of water instead of drops of mercury. Improvements began to be introduced in the details of construction, as experience revealed the imperfections. It was found that air was liable to be carried down into the pump through the supply vessel at such times as more mercury was poured in above. It was necessary to trap off such air bubbles to prevent them from vitiating the vacuum already attained. It was found necessary to introduce vessels containing drying materials, such as concentrated sulphuric acid or glacial phosphoric acid. The fall tubes were found to have an awkward habit of cracking and breaking off just at a point thirty inches above the lower end, in consequence of the hammering action of the falling drops during the later stages of exhaustion. Better and more reliable gauges were required to verify the degree of rarefaction. Lastly, some remedy was wanted for the difficulty experienced in forcing down through the thirty inches of barometric column the last small traces of residual air in the fall tube. The falling drops hammered these residual bubbles into the mercurial column below them. The air bubbles, on their part, always tended to rise again into the upper part of the tube. Often they would stick to the wall of the glass tube, refusing to move, though the mercury continued to flow past them. The remedy of turning on a more sudden flow of mercury to sweep them out was not always successful. Indeed, when it is remembered that these last residua must be recompressed to atmospheric pressure, in order to expel them at the bottom of the tube, it would seem strange if such a method of expelling the residual air should prove effectual. Some of the desired improvements were originated by Dr. Sprengel himself, others by instrument makers, who constructed Sprengel pumps for their customers.

An improved joint, made by grinding the conical end of a glass tube into a conical socket at the end of another tube, and placing mercury in the cup surrounding the junction, was described by Dr. Sprengel.

By the year 1874‡ two modifications had come into extensive use. The mercury, instead of running direct into the pump from the supply vessel, was carried down a vertical tube, surrounded by a wider external one, so that any air bubbles accidentally carried down escaped up the wider tube instead of entering the pump. Also after passing this trap, the mercury was forced up again in a moderately wide tube, ascending to a slightly lower level than the supply vessel, and again descending. The upper bend of this tube communicated at its highest point with a small stoppered chamber, partially exhausted of air by filling it with mercury, which was then allowed to run out. As the mercury passed over this bend, it consequently fell through a partially exhausted space, and was still more thoroughly freed from air before ascending to the head of the actual pump. These improvements are embodied along with others in the form constructed by Alvergniat,§ of Paris, who worked for and with the advice of M. H. Sainte-Claire Deville.

In most of the modern Sprengel pumps the mercury is introduced into the pump head by a jet tube with a narrow orifice, whence it spurts in a fine stream, and falls into the widened tube of the fall tube. In some other forms it merely breaks away in drops over a bend in a wider tube. This form is simpler to construct.

A very important addition was the improved gauge introduced by McLeod, ‖ in which was applied the principle of compressing a known volume of the rarefied air or gas into a smaller known volume (the ratio of the two volumes being accurately known) and then measuring its pressure, and so calculating backward. This method, suggested long before by Arago, and employed by Regnault ¶ for the purpose of testing the perfection of the vacuum of a barometer, may be regarded as a refinement upon the method of the "pear gauge" invented by Smeaton. In Smeaton's invention the residual air left in the pear-shaped glass vessel, placed with its lower end in mercury, under the receiver of an air pump, was, on the restoration of the external pressure, driven out of the body of the pear into its narrow upper end, where its volume could readily be measured. In McLeod's original gauge a globe of about forty-eight cubic centimeters was employed, opening at the top into a narrow volume tube sealed at the top, and suitably graduated. This apparatus communicated below with the pump, and stood at the top of a barometric column which was provided at its foot with a flexible rubber tube and a supply vessel, by raising which (by an action like that of Geissler's pump) the mercury could flow up into the gauge, and force the residual air in the bulb into the volume tube at the top. A neighboring pressure tube rendered the increment of pressure (due to compression) evident at a glance, and all that remained to be done

* Graham. "Journ. Chem. Soc.," xx., 247, 1866. See also "Pogg. Ann.," cxxix., 563, 1866.

† Bunsen. "Ann. Chem. Pharm.," cxlviii., 277, 1868. See also "Ann. Chem. Pharm.," clxv., 159, and "Phil. Mag.," xlv., 153, Feb., 1873. Compare also with water pump of M. W. Johnson, "Chem. Soc. Quart. Journal," 1852, p. 186.

‡ See E. J. Osmond in "English Mechanic," xix., 372, 1874, giving drawing of Sprengel pump.

§ Alvergniat's form is depicted in Violle's "Cours de Physiqué" (1884), I., 947. The form commonly used in Germany is given in Weinhold's "Physikalische Demonstrationen" (1881), 171.

‖ McLeod. See "Phil. Mag." (4) xlviii., 110, 1874, and "Proc. Phys. Soc. Lond.," i., 30, 1874.

¶ Regnault. "Relation des Experiences" (1847), i., 491.

was to multiply this increment by the ratio between the volume now occupied by the residual air and volume it originally occupied. McLeod showed how to carry the calculation to a second approximation.

About the same time, Crookes* introduced several improvements in detail: A method of lowering the supply vessel to refill it with the mercury that had run through the pump, the use of taps made wholly of platinum to insure tightness, the use of a spark gauge to test the perfection of the vacuum by observing the nature of an electric spark in it, the use of an air trap in the tube leading up to the pump head, the method of connecting the pump with the object to be exhausted, by means of a thin, flexible, spiral glass tube, the method of cleansing the fall tube by letting in a little strong sulphuric acid through a stoppered valve in the head of the pump. In carrying out these experiments, Crookes was assisted by Mr. Gimingham, whose further contributions to the development of the pump will presently be noticed. It was with this improved pattern of Sprengel that Crookes was able to carry out that remarkable series of researches upon the repulsion accompanying radiation which culminated, in 1875, in the invention of the radiometer, and later led to the discovery of the phenomena of "radiant matter."

Professor R. A. Mees† described another modification, the fall tube being constructed with a series of bends constituting fluid valves or traps, in which the minute portions of air carried down the fall tube might accumulate in order to be swept out the more effectually when aggregated in larger bubbles. This pump also had a peculiar automatic stop cock.

From 1875 to 1884 a series of modifications were introduced by Mr. Gimingham.‡ First, the process of exhaustion was accelerated by the employment of multiple fall tubes, receiving their streams from a distributing jet within the pump head. Three fall tubes were employed, then five, later seven, but five appears to be a preferable number. In Fig. 23, which embodies Gimingham's various improvements with the earlier ones of Crookes, there are five fall tubes shown. Careful experiments to determine the best size of bore for the fall tubes gave the following results when exhausting a vessel of 136 cubic centimeters capacity:

Diameter of Bore in Millimeters.	Rate of Flow in Cubic Centimeters per Minute.	Total Quantity of Mercury (in Cubic Centimeters) Requisite to Reduce Pressure to one Millimeter of Mercury.	Total Time Required in Minutes.
2·4	83·3	2,500	30
2·4	20	1,600	80
1·8	20	700	35
1·8	50	1,200	24
1·4	10	1,800	180
1·4	25	2,700	120
1·1	20	4,000	200

The enormous time required in the last case was due to incessant choking up of the upper part of the fall tube, owing to friction in the narrow bore. The conclusion derived from comparison of results with varying bores is that at high degrees of exhaustion the last portions of air or gas are carried out by entanglement with the mercury, and not by the mercury acting in definite "pistons" to sweep out the gas. With respect to the length of the fall tubes, it was found that those 39 inches (1 meter) long, giving a fall of 9 inches (or 22·5 centimeters), exhausted more rapidly than tubes only 33 inches (85 centimeters) long. Tubes longer than 39 inches were found liable to fracture, in consequence of the severe concussions of the mercury as it fell upon the top of the barometric column. Gimingham also described an improvement in the McLeod gauge, making its indications at once more sensitive and more reliable. Several minor improvements are also mentioned. An improved vacuum tap, an improved form of air trap, a radiometer gauge, and a bulb containing crumpled gold leaf, to absorb mercury vapor.

The lettering in Fig. 23, which is taken from Gimingham's paper in the "Journal of the Society of Chemical Industry," is as follows: The supply vessel, A, communicates by a long tube with a forked tube, C, leading to two regulating pinch cocks, *r* and *q*. The left-hand tube leads up through two air taps, *n* and *m*, to the McLeod gauge; the right hand tube, through two air traps, *n* and *i*, to the pump head, where the mercury is thrown in jets into the tops of the five fall tubes. The tube, *t*, is the exhaust tube, which has three branches, one, *s*, leading to the McLeod gauge, one, *l*, leading to the barometric gauge, *u*, and one leading through the drying tube, *x*, and the absorbing tube, *y*, to vessel, lamp, or bulb, which is to be exhausted. A comparison barometer is placed at *v*, and a measuring rod to read off barometric heights is fixed at *w*. The arrangements at *d*, *e*, *f*, and *g* relate to a mechanical method of counting the number of times that the supply vessel has been let down to be replenished.

Mr. Gimingham has also suggested § a mechanical mercurial pump with valves.

A five-fall Sprengel pump, of simpler construction, and jointed with India rubber tube joints, is used by the Thomson-Houston company, in their factory at Lynn, Mass. The Anglo-American (Brush) company have also used a modified five-fall tube in their works at Lambeth. Another multiple fall pump has been patented by Mr. Donkin.‖

* Crookes. "Proc. Roy. Soc.," xxxi., 448, 1881. Also "Proc. Phys. Soc. Lond.," i., 35, 1874.

† Mees. See "Catalogue of Loan Collection of Scientific Apparatus," 1876, p. 131.

‡ Gimingham. "On a New Form of the Sprengel Air Pump." "Proc. Roy. Soc.," clxxvi., 396, 1876, and "Contributions to Development of Sprengel Air Pump." "Journ. Soc. Chem. Indust.," 1884.

§ Gimingham. See "English Mechanic," xxxvi., 442, 1882.

‖ Donkin. Centralblatt fur Optik und Mechanik, vii., 216, 1886.

Dr. L. Von Babo* described an ingenious method of making the Sprengel pump supply itself with mercury, by the device of connecting it to a water aspirator, worked by a constant stream of water. This aspirator drew in air and mercury at the lower part of the pump, and lifted it up through a narrow tube to a height above the level of the mercury in the supply vessel. Incidentally, this method has the advantage, apparently not noticed by Von Babo, of enabling the fall tube to be considerably shortened. It has the disadvantage of exposing the mercury to water vapor during a part of its circulation.

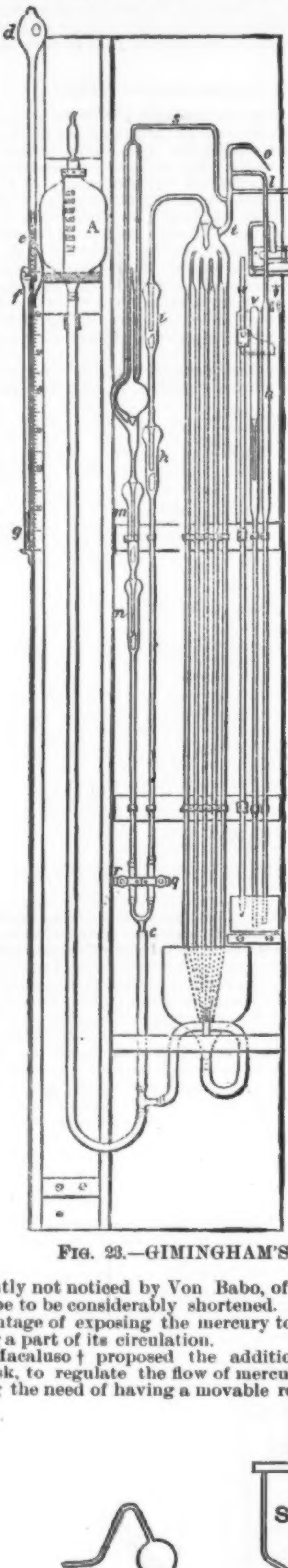


FIG. 23.—GIMINGHAM'S PUMP.

Macaluso† proposed the addition of a Mariotte's flask, to regulate the flow of mercury, thereby avoiding the need of having a movable reservoir.

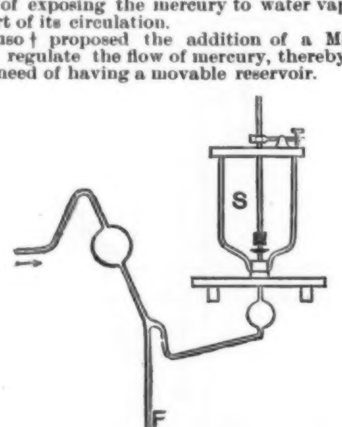


FIG. 24.—ROOD'S PUMP.

Rood,‡ in 1880, described several details of some novelty. An iron valve in the bottom of the supply vessel, capable of fine regulation by a screw, served to determine the rate of flow of the mercury. Immediately below the supply vessel, the mercury entered a vacuum bulb (see Fig. 24), designed to free the mercury from air and moisture, the mercury dropping at once to its lower part, which should be level with the point where the curved supply tube joins the fall tube. This bent tube, about 20 centimeters long, after descending gently, ascends about 4·5 centimeters. It is made of about the same diameter in the fall-tube. The fall tube, as in Mees' pump, is provided with bends. Rood also described a modification of the McLeod gauge. His pump was so mounted that all parts of it could be heated by means of a Bunsen's burner. Great importance was attached by this experimenter to this point; as it appeared that much higher exhaustion was thereby attained.

* Von Babo. "Berichten d. naturforsch. Gesellsch. zu Freiburg," ii., Heft. 3, 1879.

† Macaluso. See "Wied. Beibl.," iv., 516. 1880.

‡ O. N. Rood. "Sillim. Journ.," xx., 57, 1880; ib., xxii., 90, 1881. See also *New York Times*, Nov. 19, 1880.

In 1882, Hannay* proposed to replace the mercury by a fusible alloy of lead, bismuth, and tin, melting at 94°; by this means it was thought that the necessary imperfections arising from the pressure of mercury vapor would be avoided.

The Sprengel pump employed by the Edison company (New York, 1885) in the manufacture of glow lamps has a simple fall tube cemented (as shown in Fig. 25) at its lower end into an iron tube, E, which

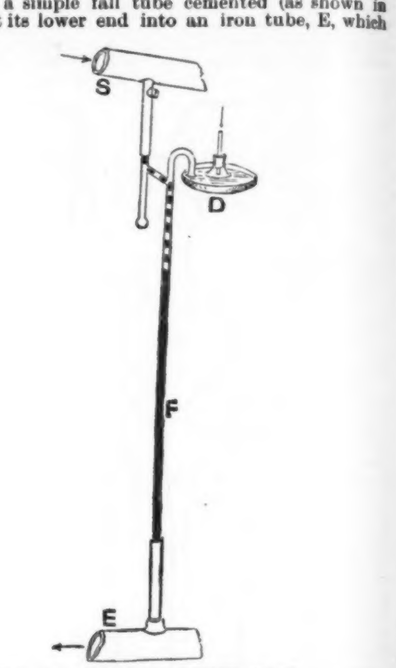


FIG. 25.—EDISON PUMP (1885).

carries away the ejected air and mercury from a series of such pumps. An iron supply pipe overhead feeds the pumps. Strong sulphuric acid placed in a shallow glass vessel, D, is used for drying.

(*To be continued.*)

MAGNETIC SEPARATOR.

THE new type of magnetic or electro-magnetic separators are absolutely indispensable in large workshops, where considerable quantities of filings and turnings of all sorts accumulate daily, among which those containing copper are the only ones of value, provided they are separated from the particles of iron generally found mixed with them in variable quantity. The type of separator here shown is used in the arsenals and government shops in England. It is made by Collier & Co., of Manchester. The action of the apparatus is easily understood from the cut. A series of small horseshoe magnets are attached to wooden cross pieces carried by two endless chains kept in continuous rotation. The metal filings are thrown into the lower part into a semi-cylindrical receptacle, and the

MAGNETIC SEPARATOR.

* Hannay. "Philos. Magaz." [5] xiii., 229, 1882.

particles of iron attracted to the magnets are carried to the upper part, where a brush removes them, letting them fall into a special conduit. The magnets thus are always clean when they enter into the mass to be cleaned. When this has been sufficiently purified, the apparatus is discharged by opening the lower receptacle, after which the machine is again charged.—*Electricité.*

[Continued from SUPPLEMENT, No. 629, p. 10053.]

CHEMICAL AND ALLIED INDUSTRIES.*

By WATSON SMITH, Lecturer in Chemical Technology in the Victoria University, etc.

GROUP VI.—FINE CHEMICALS, ALKALOIDS, ESSENCES, AND EXTRACTS.

Messrs. James Woolley, Sons & Co., Manchester (No. 785), exhibit an interesting collection of drugs of vegetable origin recently adopted as remedial agents, and solid and liquid preparations thereof adapted for medicinal use. Among the new remedies shown of vegetable origin are cocaine and strophanthus; while among those of coal tar origin are antipyrine, antifebrine, and salol. Every one has heard of the deadly Kombé arrow poison, used by the natives of the African coast. This poison is the extract of the seeds of the strophanthus plant, and the chemical principle, a glucoside, is termed strophanthin. Mr. William Elborne, of the Owens College, has succeeded in isolating this poisonous glucoside in a state of purity. In small doses it is being used extensively in medicine as a valuable remedy in certain forms of heart disease. There are also specimens of various solid and fluid extracts, besides preparations of cinchona, opium, and nux vomica as directed by the "British Pharmacopœia" of 1885 to contain a definite proportion of active principle. The oleates shown are of considerable interest, and are prepared both by double decomposition and direct combination. They are principally used in dermatology. Besides these are to be seen ointments, pills coated by a soluble covering so as to temporarily conceal taste and odor, and a specially prepared cod liver oil, with emulsions of the same, etc.

Thomas Christy & Co., 25 Lime street, London, E. C. (No. 787).—An interesting collection, containing in the dried state a variety of the plants, nuts, fruit, etc., from which the principal medicaments, extracts, alkaloids, and essences—as well as foods—of vegetable origin are obtained. Besides these are also shown the prepared essences and other medicaments. It may not occur to those who admire the large quantities of rare alkaloids and extract preparations exhibited in some of the neighboring show cases to Messrs. Christy's to inquire, "Where are the raw plants and drugs, nuts, roots, etc., obtained, from which these preparations are made?" The reply is, Messrs. Thomas Christy & Co. is one of the few firms in existence for collecting these. Among pharmacologists Mr. Thomas Christy's interesting periodical, "New Plants and Drugs," is well known, but a staff of experts is kept employed in foreign lands whose duty it is to investigate and report to headquarters, with the object of bringing new drugs and extracts to light. This firm has now a very considerable stock of raw plants and drugs, which, being convinced must be used some time, they offer to supply samples of to practical experimenters and scientific investigators for their researches. The exhibit is a collection of raw and manufactured drugs and their preparations, menthol and menthol cones, barks of various kinds, fibers, different specimens of gutta percha, rubbers, tanning barks, dyewoods, etc., together with many other materials and finished products.

Messrs. Howards & Sons, Stratford, London, E. (No. 792).—Messrs. Howards & Sons have probably done more than any firm in practical experimental research and commercial enterprise to place fine quinine, as well as other preparations, at a moderate price in the market. Exceedingly fine and tastefully arranged specimens of cinchona barks and alkaloids are exhibited, as well as an interesting variety of organic acids and alkaloids used in pharmacy. The samples shown illustrate the great change which the introduction of cultivated bark has brought about in the quinine industry. The alkaloids exhibited by this firm are extremely pure. A beautifully crystallized specimen of iodoform is exhibited as the manufacture of Messrs. Howards. Specimens of coca leaves, of the cocaine alkaloids and their salts, and of benzoyl-ecgonine, obtained by heating cocaine with concentrated hydrochloric acid, are also shown.

E. Merck, Darmstadt, London, and New York (No. 788).—This firm, so well known for pharmaceutical preparations, alkaloids, and similar chemicals, makes a fine display. Without attempting to describe all the features of interest in the show case of this firm, some preparations and substances found useful in the case of the most recent remedial efforts may be desirable. In the first place, a colorless sirupy liquid is shown, *Lactic acid. alb.*, of specific gravity 1·21. It has been lately recommended by Mosetig-Moorhof for the purpose of destroying morbid and unnatural growths and formations. Internally used, it is recommended for diabetes, 5 : 300 per diem. A splendid specimen of *Aconitine nitrate cryst.* (Merck) is also to be seen. It is prepared from *Aconitum napellus* by Duquesnel's method. The salt appears in the form of colorless crystals, soluble in water and alcohol. Its action on the animal economy is much more intense than that of the amorphous aconitine; it is, in fact, one of the strongest poisons known. The consumption in England and France is very considerable. Another specimen of great interest for the physician and student of medicine is that of *Apomorphine hydrochloride cryst.* It is a salt in the form of colorless crystals, soluble both in water and alcohol. The solution on exposure to air and light becomes gradually green, but the change is said not to diminish its physiological effect. Apomorphine is a certain emetic, 0·004 to 0·01 grm. causing vomiting within six minutes. A valuable principle is the glucoside *arbutin*, which is exhibited in white crystals. It is contained, along with tannic acid, gallic acid, and ursone, in the leaves of *Uvæ ursi.* Arbutin is easily soluble in water, but less so in alcohol, and it has a bitter taste. Even large doses do not produce fatal effects. It is a valuable medicine in the treatment of inflammatory catarrh of the bladder. The usual dose is three to four grms. in solution or as powder. Specimens of *atropine* and its *sulphate*, of rare beauty as well as bulk, are shown. *Atropine*, melting at 239° Fahr. (Merck), absolutely pure, and especially free from daturine (so-called light atropine). The high melting point proves this. Moreover, its purity is indicated by its being in very hard, bright, and heavy crystals. Preparations containing daturine have a much lower melting point (about 223° to 226° Fahr.), and are never seen in such fine crystals as those which are free from it. *Atropine sulphate white cryst. neutral* (Merck): Extremely pure and absolutely neutral. A solution of 1 in 1000 produces mydriasis after 15 minutes; solutions of 1 in 200 have the same effect in from five to ten minutes. The internal use of atropine as anti-spasmodic, anodyne, and sedative, as well as a means for limiting certain secretions, has increased, and especially since atropine has been recognized as a powerful *antagonist* to different narcotic poisons, such as morphine, digitaline, prussic acid, etc. Thus the most reliable antidote to atropine would be repeated injections of morphia, accompanied with skin excitation and artificial respiration. This property and fact of the antagonism of symptoms produced by certain alkaloids and principles is very singular, and likely to prove of great value in medical practice. It was referred to by Professor Leech at the pharmaceutical conference recently held in Manchester. Since the increase in demand for *belladonna* root, and the consequent rise in price, the cheaper root of a kind of scopolia (false belladonna) has been extensively placed in the market, and has found a ready sale. The fact of many makes of atropia sulphate having varying melting points is thus accounted for. An interesting alkaloid shown is *berberine.* It is found in the *Berberis vulgaris L.*, and also in many other plants. The specimen, a very fine one, is in glittering reddish brown crystalline scales, which begin to sublime at 392° F. The alkaloid is not readily soluble in cold water, but easily soluble in hot water and in alcohol, and nearly insoluble in ether and carbon bisulphide. The salts, hydrochloride and phosphate of *berberine*, which are also exhibited, are readily soluble and are easily absorbed. The dose for indigestion and diarrhœa is about one grm. per diem. It is used also in cases of sickness during pregnancy and malaria.

A beautiful series of salts of *caffeine* is shown, *e. g.*, the benzoate, hydrobromide, hydrochloride, nitrate, salicylate, sulphate, valerianate, sodio-benzoate containing 45·8 per cent. of caffeine, sodio-cinnamylate with 62·5 per cent. of caffeine, etc. Mr. Merck made an interesting report on these salts and double salts as soon as he had succeeded in producing them in the form of true salts, especially the easily soluble double ones, instead of the indefinite mixtures hitherto known. According to Merck, Riegel and other investigators proposed these new compounds as substitutes for *digitalis*—a proposal of the greatest importance to the medical world. The effect of the injection of caffeine is perceived at once, and collateral effects, especially those of a cumulative nature, are absolutely excluded.

Camphor Monobromide and Dibromide.—Of these compounds the monobromide is chiefly in demand. It is but slightly soluble in water and glycerine. As sedatives these preparations are used for epilepsy (subcutaneously 0·1 grm. dissolved in oil), for chorea, migraine, nervous palpitations of the heart (internally 0·1 grm. to 0·5 grm. in wafers); while in cases of delirium tremens doses of 1·5 grms. are given. Fine specimens are shown of both these salts. An important compound, also shown, is Merck's *Cannabine tannate.* It serves in many respects successfully as a substitute for morphia, and together with the preparation named *cannabinone* (a 10 per cent. trituration) we have two valuable hypnotics showing no unpleasant after-effects. The raw material is obtained from the *Cannabis indica*, a variety of the *Cannabis sativo L.* (*Uticaceæ*). The tannate is given in doses of 0·25 grm. to 0·1 grm.; in cases of delirium 1·5 grm. The cannabinone (pure) is administered in doses of 0·05 grm. to 0·1 grm. The rare metal *cerium*, in the form of its oxalic acid salt, even serves as a valuable medicament, and a sample of pure cerium oxalate is to be seen as a white granular powder, insoluble in water and alcohol, but soluble in hydrochloric acid. The dose is 0·05 grm. to 0·15 grm. It is used as an antidote to catarrhal affections of the stomach and bowels, sickness during pregnancy, and epilepsy. *Chrysarobin* prepared from *Goa powder* is another specimen of interest. This preparation is absorbed by the skin, and has thereby a stimulating effect. It produces vomiting and diarrhœa, and has a stimulating effect on the kidneys; this is the case also when applied externally. It is chiefly used for psoriasis.

Among the finest specimens are the *cocaine preparations*, of which the hydrochloride and salicylate are shown. The hydrochloride is granular, crystalline, and white, and free from every impurity. Dr. Karl Koller, of Vienna, was the first to draw attention to the local anæsthetic properties of cocaine, and to turn them to account. Dr. Brettauer, at Koller's request, explained and exemplified the discovery on the 17th and 18th September, 1884, before the Ophthalmological Society of Heidelberg. It is proposed to use the cocaine in various ways. Emmert, in the treatment of the eye, proposes to use it as a salve with vaseline; Fodor to use it alone. To make its solutions keep well, many additions have been proposed. The simplest is an addition of glycerine. In tuberculous disorders of the air passages Meyer-Huni recommends inhalations of cocaine. Most painful injections of corrosive sublimate are made quite bearable by first adding to the mercurial solution only 0·05 grm. of cocaine per dose. Randolph and Dixon commend a concentrated solution of cocaine hydrochloride in nitric acid as a painless causticizing agent; the wound to be bound up with a bandage covered with cocaine salicylate. The best antidote against poisoning with cocaine is amyl nitrite, according to Schilling. When cocaine is heated with strong hydrochloric acid it decomposes, forming benzoic acid, methyl alcohol, and *ecgonine*, a specimen of which is exhibited. *Ecgonine* was first discovered in Merck's laboratory.

Specimens of pure crystallized *codeine*, its soluble phosphate and salicylate, much in favor on account of stability of the solutions, are shown. The phosphate dissolves in four parts of water, and the solution, subcutaneously injected, produces no pain or reaction at the place of incision. The dose of the phosphate for diabetes Merck gives as 0·06 grm. three times daily, increasing by 0·06 grm. every eight days up to 0·54 grm.; cod liver oil is taken at the same time. *Codeine* is a methylmorphine.

Another useful vegeto-alkaloid, exhibited in fine crystalline condition, is *colchicine.* It is found in all parts of the meadow saffron (*Colchicum autumnale L.*), and is a very strong poison. In doses of 0·0005 up to 0·002 grm., two or three times a day, it is a remedy for gout and rheumatism. For subcutaneous injection it is not to be recommended. For complaints of a convulsive nature, spasmus glottidis, tussis convulsiva, asthma, etc., a valuable remedy is coniine in the form of its salts. *Coniine* is an alkaloid of the *Conium maculatum L.*, which plant also contains two other alkaloids, conydrine and methyl-coniine. Our knowledge of the chemical constitution of coniine we owe to Hofmann and Ladenburg. Coniine has been recommended and used by Muraweiff for toothache caused by decayed teeth. The pain ceases through the paralysis of the nerves. Of course the alkaloid is directly applied to the exposed nerve. Very remarkable is the antagonism of certain highly poisonous substances. Such antagonism exists between coniine and brucine, for coniine, as Hugo Schulz has shown, paralyzes the symptoms of brucine poisoning. Pure coniine is a colorless oily liquid, while the salts take the crystalline form. The hydrochloride crystallizes best. The hydrobromide is a very constant compound, and contains a definite quantity of coniine. It is readily soluble in water, and thus easy to administer. The dose of coniine hydrobromide is 0·001 to 0·02 grm. several times daily. Fine specimens of the above two salts are to be seen in the exhibit.

Cotoine and *paracotoine* are very interesting bodies, about which as yet very little is chemically shown. Messrs. Merck show fine specimens of both in the pure state. Since the year 1873, various barks have been introduced into the market, which it was believed would replace the quinine or cinchona barks. These drugs were brought from Bolivia, though still more recently the old forests of Brazil have been made to furnish them. The barks mentioned appear to come from a species of *Rubiaceæ.* However, the crystallizable principle cotoine was first isolated by Hesse, and it has the composition $C_{22}H_{18}O_6$. It is soluble with difficulty in cold water, easily in hot, also in alcohol and ether. Cotoine and paracotoine are styptics, and have been found useful against diarrhœa and excessive perspiration. Particularly must cotoine be considered as a preventive of diarrhœa in children and in cases of phthisis. The doses vary from 0·05 to 0·1 grm. for cotoine and 0·1 to 0·2 grm. for paracotoine. The relations of cotoine and paracotoine to each other seem to be remarkably similar to those of quinine and cinchonine.

Another rival of quinine is *ditaine*, of which a well crystallized specimen is shown. It is a crystalline substance obtained from *Alstonia scholaris L.*, an apocynea found in the East Indian islands. Ditaine, it is stated, has effects similar to those of quinine, and is recommended against intermittent fevers.

A finely crystallized specimen of *ethoxy-caffeine* is exhibited. It takes the form of needle-shaped crystals, melting at 284° F., very little soluble in alcohol and ether, insoluble in water, and of very basic properties. The dose varies from 0·25 to 1 grm. per diem. Ethoxy-caffeine is a sedative and a narcotic, and is of value in the treatment of migraine in cases where other medicines do not produce any effect.

Another very pure and beautiful preparation is *Merck's helenine.* This is shown in the absolutely pure state, melting at 230° F., and consisting of colorless neutral crystalline needles. At one time an impure so-called helenine was used, and consisted mainly of powdered alant root. However, serious, even fatal, results followed the use of it, owing to other and foreign substances present. Merck now offers only the absolutely pure alkaloid. It is used for diseases of the respiratory organs, for reducing inflammation, and is said to speedily relieve chronic bronchitis.

Hydrastine (pure crystallized), and *hydrastine tartrate* (pure, neutral).—The first of these interesting preparations is the alkaloid of the *Hydrastis Canadensis L.*, a ranunculacean plant found in North America. Pure hydrastine is almost insoluble in water, but the tartrate dissolves easily. In America hydrastine is recommended as an anti-periodic for fever with inclination to profuse diarrhœa, for certain diseases of the eye, of the skin, for hemorrhoids, etc. In Germany it is sometimes prescribed for its effect in contracting the uterus.

Hyoscyamine (pure and crystallized), from *Hyoscyamus niger.*—This is perhaps one of the most extraordinary of the alkaloids as regards the remarkable results in the treatment of diseases that are obtained with it. The specimens of the alkaloid and its salts, the hydrobromide and hydriodide, exhibited are perfectly pure. Hyoscyamine is isomeric with atropine and identical with daturine and duboisine. This preparation is used by oculists instead of atropine; subcutaneously as a hypnotic in cases of insanity, and as an antispasmodic in asthma, epilepsy, whooping cough, chorea, etc. The dose as a hypnotic is up to 0·005 grm. subcutaneously injected. *Pure hyoscine* is amorphous and of a sirupy form, but its salts crystallize readily. The hydrobromide and hydriodide are in chief use as medicines. E. Merck produces both hyoscine and hyoscyamine on a large scale, and he claims that the articles sold in the market are generally of his preparation. The most wonderful feature in the properties of hyoscine is the power of tranquillizing maniacs, and of all the remedies in use for this purpose it may be regarded as the most valuable on account of its prompt effect, and because it is not dangerous even to patients suffering in a high degree from heart disease. Experiments carried out by Professor R. Kobert and Dr. Sohr with hyoscine hydrochloride proved that the greater part of the hyoscine administered passes from the body through the kidneys. Doses of one milligramme of hyoscine applied subcutaneously increase the action of the heart and circulation, but have no influence on the respiration. The secretion of saliva is suspended by it, as also the action of the intestines due to nervous irritation. In therapeutics the effect of hyoscine on the healthy and the (mentally) diseased organism is of most particular importance. On the former, the effect is generally that of a narcotic, and on the latter, in all cases, the effect on excitable patients, even on raging lunatics, is sleep-producing and calming. Dr. Gamgee, F.R.S., late of the Victoria

* Report on Section III. of the Manchester Royal Jubilee Exhibition.

University, told the writer that he had observed the effect of the subcutaneous injection of about 0·001 grm. (between one and two hundredths of a grain) in the case of a maniac in a condition of which to say the strait-waistcoat and padded room were necessary would give but a mild notion of the frenzied state. That effect was a marvel; in a few seconds the patient being led away as tractable and harmless as a child, though with a stupefied and dazed expression of countenance. Of 101 subcutaneous injections of hyoscine hydrochloride in doses of ½ to 1 milligramme applied to a large number of patients in the Clinical Hospital for Mental Diseases at Dorpat during the months of July, August, September of 1886, not one failed to produce sleep, nor were in any case secondary effects observable. Almost in all kinds of diseases accompanied by periods of excitement, either sleep or a calming effect had been produced, even when other means had been tried in vain, applied for the same purpose.

A useful preparation called pure *lacmoid*, in scales, is shown. It will be of interest to chemical analysts, as a substitute for litmus. It is extremely sensitive to acids and alkalies. A useful solution for testing is recommended by Merck, as follows: 0·5 grm. lacmoid, 100 c. c. of water, and 100 c. c. of alcohol of 96 per cent. strength.

Lithium salts, the carbonate, hippurate, citrate (crystallized), and salicylate, are exhibited in great purity. The lithium salts have a more powerful diuretic effect than the salts of potassium.

Naphthalene.—Many people will look at this as a remarkable substance to propose as a medicine. If well purified, it is a valuable anti-diarrhoicum in cases of typhoid, diarrhœa, and intestinal complaints in case of phthisis. Not being absorbed by the bowels, this preparation has no general effect on the organism, but only on the mucous membrane of the bowels. Dose up to 5 grms. per diem.

Papaine.—This is a form of vegetable albumen capable of extraordinary powers of digestion, even greater than those of pepsine. It is obtained from the *Carica papaya L.* (*Papayaceæ*). One part of papaine peptonizes and renders soluble 200 parts of blood fibrin. It has been used very successfully for painting and so dissolving and removing the fatal membrane in cases of diphtheria. Merck states that most of the papaines in the market do not possess one-fourth the digestive power of his preparation.

Pilocarpine.—This alkaloid is exhibited in the pure state, and also in the form of salts, which are very fine examples as pharmaceutical preparations. The hydrobromide, hydrochloride, nitrate, and salicylate are shown, and also the pilocarpidine nitrate of Harnack-Merck. Pilocarpine is the alkaloid of the jaborandi leaves; it possesses a powerful diaphoretic salivating action. West recommends very small doses (0·005 to 0·01 grm. subcutaneously) in cases of the nocturnal sweating of consumptive patients. Pilocarpidine was discovered in E. Merck's laboratory in the process of working upon a large quantity of jaborandi leaves. Pilocarpine and pilocarpidine produce the same physiological effect. This alkaloid has recently become of enhanced interest to chemists since the mode of artificially preparing it by synthetical chemical processes has been discovered by two French chemists. Finally, magnificent specimens of strychnine in the pure crystalline state and of strychnine sulphate are exhibited. The best antidotes for this most deadly poison are paraldehyde and chloral hydrate. Fine specimens of *veratrine* are shown. Used externally, the effect is that of a stimulant to the skin, while taken internally it acts as an antipyretic.

Dr. Theodor Schuchardt, Goerlitz, Germany (No. 790).—The following are specimens of special rarity and beauty in Dr. Schuchardt's exhibit: *Metallic selenium*, its tetrachloride and tetrabromide; *tellurium*, crystallized and sublimed, and its tetrachloride; fine specimens of *germanium*, discovered by Clemens Winkler, with its sulphide and oxide; *cerous sulphate*, crystallized with five molecules of water; *yttrium nitrate*, crystallized; *erbium nitrate*; metallic *indium*, a magnificent specimen as a block, weighing 100 grammes, also its hexachloride, sulphate, hydroxide, and its double potassium chloride; *gallium*, fine specimen of the metal, its ammonium, alum, and other salts; *thorium chloride*, *tantalum chloride*, *niobium chloride*, and an interesting specimen of crystallized *osmic acid*. So much for the rare metals and their salts to be seen in this instructive cabinet. Among the organic preparations we note the following, of which it will not be easy to find similar examples, if examples at all, in the chemical collections and museums in this country: α-Naphthoquinone and β-naphthoquinone (well crystallized); *eupittonic acid*, the interesting coloring principle found in wood naphtha and wood tar. The following are derived from or contained in coal tar: Pyrene, together with its fine red picrate, so characteristic of it; chrysene, a magnificent specimen, pure white and crystalline; durene (tetramethyl-benzene), only recently discovered by K. E. Schulze in coal tar; acenaphthene and pseudo-cumene, hydrocarbons of coal tar. Thiophen and thiotolen, recently discovered by Victor Meyer. The phenol of thiotolen is also exhibited, together with a series of thiophen compounds, etc. α-α-Lutidine and α-γ-lutidine are finely exemplified; also the phenyl and tolyl pyrrols. Besides these are the following: Crystallized sorbin and dextrose, galactose, inulin, a crystallized compound of dextrose with sodium chloride and a molecule of water; arabinose, inosite (crystallized), levulose, and maltose (crystallized). Among coloring matters are: Orcein, dimethyl-*p*-phenylenediamine, tetramethyl-*p*-phenylenediamine, metaphenylenediamine, chlorophyl, phyllopurpurin, pyrrol red, etc.; while as specimens interesting to the pharmaceutical chemist are: Hypnone (crystallized), glutamine hydrochloride, umbelliferone, terebene, sylvestrene, pinene, champhene (crystallized), limonene, borneol (artificial crystallized and natural crystallized), terebine hydrochloride, curarine hydrochloride, helenine (crystallized), tyrosine (crystallized), alloxan (crystallized), and finally tincture of strophanthus.

Messrs. Kay Brothers, Lower Hillgate and St. Petersgate, Stockport (No. 794), exhibit a miscellaneous collection, comprising the following: Simple and compound essences, extracts, etc., absorbent and antiseptic cotton wools—*e. g.*, pure absorbent, carbolized, sublimated, salicylated, and iodoformed. Glass valve tubes (Kay's patent). Disinfectants, a fusible cement for stone and iron work. Perfumery, sirups, medicinal extracts and essences of ginger, peppermint, sarsaparilla, taraxacum, and ergot. Among medicinal oils we note those of cod liver, castor, linseed, cotton seed, mustard seed, sweet almond, olive, sperm, and lard.

Grimshaw Brothers, Canal Chemical Works, Clayton, Manchester (No. 786).—This exhibit may be divided into three series:

1. Zinc compounds used in manufactures and pharmacy, the chief of these being (*a*) chloride of zinc in the solid and liquid state, the former run hot into lead-lined casks for export (Messrs. Grimshaw were the first who made it largely in this form); (*b*) sulphate of zinc, commercial, and chemically pure. These articles are largely used in the sizing of cotton goods for the prevention of mildew; (*c*) sulphide of zinc, for rubber purposes and as a white pigment. Among the other zinc salts are ferrochanide, silicate, carbonate, acetate, nitrate, oxide, tannate, bromide, iodide, chromate, phosphate, etc. Probably never before has such a complete set of commercial zinc compounds been shown. The spelter and the zinc ores and minerals which are the natural sources of zinc compounds are also to be seen.

2. Sizing materials for cotton warps and piece goods, also materials used in finishing the same.

3. Recovered India rubber, substitutes for India rubber, and chemicals and drugs used in the rubber manufacture. The recovered rubber consists of qualities which range in value from what is almost equal in value to native Para rubber down to qualities which are lower in price than the cheapest native rubber.

The substitutes for rubber are of lower value still. They are (many of them) more lasting in their nature than many forms of real rubber. Both the recovered rubbers and the substitutes are generally used incorporated with new rubbers. The color of the substitutes varies from dark brown to white, according to their nature and the particular use to which they are put.

The rubber chemicals are used for vulcanizing rubber, or coloring it, or giving it body, and consist of such substances as oxide of zinc, sulphide of zinc, sulphide of antimony (red), sulphide of lead, hyposulphite (thiosulphate) of lead, and many of the pigment colors which are used in paints. The rule in using these is that they must not be such as will be affected by combining with the sulphur in the vulcanization process.

Vesuvian white is a special vulcanizing material which Grimshaw Brothers make for use in the manufacture of tennis balls and some other articles. This firm also shows some solvents of rubber—viz., solvent naphtha, chloride of sulphur, bisulphide of carbon, etc., also India rubber solution or varnish. In addition to the above three series, the following are illustrated:

H. Grimshaw's patent process for separating and utilizing the zinc and iron of galvanizers' waste. The zinc is dissolved by an acid solution of chloride of zinc, which thereby becomes more concentrated, and the iron is left in a pure state. The galvanized waste cannot be smelted, as the zinc makes the iron "short" or "brittle," whereas the iron after it has been treated becomes adapted for working up again.—*Journal of the Society of Chemical Industry.*

A NEW PHOTOMETER FOR USE IN THE FIELD.

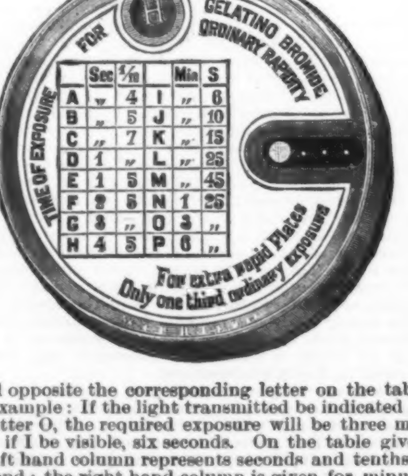
The arrangement of the instrument is very clever and ingenious, and we have not met with any apparatus of the class which pleases us so much as that now before us.

The block shows the actual area of the photometer, and it is about half an inch thick. Virtually, it is a brass box with a revolving disk inside it, and this carries a series of increasingly opaque windows which are brought in succession under the long opening shown at the east side of the diagram, each of the windows corresponding to a letter which becomes visible at the round opening shown near the north of the sketch.

The method of using the photometer is as follows:

Having focused the picture and inserted the diaphragm, place the photometer against the ground glass with the most transparent series of windows over the half tones of the picture, viz., over such parts as are neither very strong in high lights nor in dense shadow. Now, with the head still covered by the focusing cloth, carefully turn the center button from left to right, keeping the eye about 18 inches away from the aperture, when it will be found that the light admitted through the three small holes at the side of the larger one will become gradually less until they become almost undiscernible, but leaving the larger aperture still visible.

When this is attained, remove the instrument and ascertain the letter visible in the circular aperture at the back. The necessary exposure will at once be



found opposite the corresponding letter on the table. For example: If the light transmitted be indicated by the letter O, the required exposure will be three minutes; if I be visible, six seconds. On the table given, the left hand column represents seconds and tenths of a second; the right hand column is given for minutes and parts of a minute.

The exposures tabulated on the photometer are for plates of average rapidity—a somewhat vague expression, but still giving some notion of what is meant. Indeed, all will understand that a photometer such as now described can only give an approximation, but nevertheless may be of very essential service to one not constantly at work.—*Photographic News.*

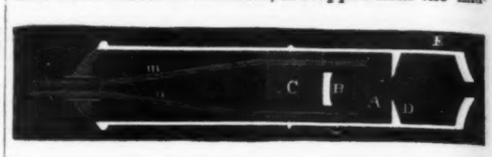
A NEW INSTRUMENT FOR THE MEASUREMENT OF RADIATION.

By C. C. Hutchins.

The difficulties which attend the use of the thermo-pile as an accurate measurer of radiations are familiar to all who have had any experience with that instrument. The slowness of its indications, and the long time required for it to return to zero, are defects which entirely unfit it for many delicate experiments.

It occurred to the writer that sensitiveness to radiation might as well be secured by employing a very thin thermal junction with some condensing arrangement, as by the use of several pairs of stout bars, as in the ordinary thermo-pile. For the thin junction would be heated to a much higher temperature than a thick one by a given quantity of heat, and have the great advantage of quickly parting with its heat and returning to the temperature of the surrounding atmosphere.

The instrument is constructed upon these principles as follows: A tube of vulcanite ten inches long, two and a half inches in diameter, is stopped near the mid-



E, tube of vulcanite; C, plug of wood; *m*, *n*, copper rods; A, thermal junction; B, concave mirror; D, stop.

dle by a plug of wood. The tube is made separable, and this plug serves to unite its two halves as well as to support the working parts. Through the plug pass two small copper rods projecting about an inch above the plug toward the front of the instrument, and passing out through its back, were they serve to attach wires extending to a galvanometer.

The thermal junction is made by uniting with hard solder a bit of watch spring and a bit of flattened copper wire. The whole is then worked to a ribbon 1 mm. wide, 0·03 mm. thick, and 25 mm. long. The two ends of this ribbon are then soldered to the two copper rods, so that the junction may be midway between them.

A concave mirror of glass, silvered upon first surface, is so secured upon the plug that the junction is exactly at its focus. The front of the tube is provided with an opening of any convenient size, and stops to limit the diameter of the entering ray.

The accompanying sketch will make the details clear. Its working has been very satisfactory. It requires no longer to return to zero than for the galvanometer needle to come to rest, and is correspondingly rapid and dead beat in its action. It is much more sensitive than a thermo-pile of the same exposed area.

An instrument in actual use having an opening of 8 mm. deflects its galvanometer 30 divisions of its scale when the hand is held a foot from the opening. A lighted match at six feet drives the needle around to its stop.—*American Journal of Science.*

[Nature.]

ISOLATION OF FLUORINE.

One of the most difficult problems of modern chemistry has at last been satisfactorily solved. After three years of incessant labor, occasionally interrupted by temporary feelings akin to despair, M. Henri Moissan has at length isolated in considerable quantities that most baffling of elements, flourine, and has been enabled to determine its principal properties. The experiments themselves are among the most interesting ever performed, and their details, as described by M. Moissan in the December number of the *Annales de Chimie et de Physique*, form most fascinating reading. They must of necessity have been extremely costly, for by far the greater portion of the apparatus employed was constructed of platinum, and it is not often that one hears of a platinum tube 80 centimeters long and of 1½ centimeters diameter being destroyed in each experiment, as happened in the earlier stages of these researches.

The isolation of flourine has formed a worthy object of the attention of chemists ever since the first remarkable experiments of Sir Humphry Davy, who was rendered dangerously ill by being exposed to the corrosive fumes of hydrofluoric acid. Although Davy was not successful in obtaining free fluorine, yet he brought clearly to light the nature of hydrofluoric acid, and proved it to consist of hydrogen combined with an unknown but extremely active element—fluorine. The history of all the attempts which have since been made to effect the preparation of free fluorine might occupy a volume, and it will therefore only be necessary to refer to the later work of our countryman Gore, who, in 1869, published his researches upon the electrolysis of hydrofluoric acid, and of certain fluorides, and left our knowledge of the acid itself in a most complete state. M. Moissan, working in the laboratory of M. Debray, now steps in and achieves the result so ardently sought after during the last eighty years—another example of the irresistible power of human perseverance.

In the light of the experience gained by former experimenters, it appeared that the action of a powerful electric current upon the compounds of fluorine with the non-metallic elements, such as hydrogen, phosphorus, and arsenic, would be most likely to yield the desired result; knowing also that fluorine must be an extremely energetic substance, it was absolutely essential to work at very low temperatures. Hence M. Moissan's first attack was made upon the fluorides of phosphorus and arsenic, but finding these to be practically impregnable, he diverted his attack, guided by certain indications afforded during his first attempt, upon hydrofluoric acid itself. Finding, however, that

pure hydrofluoric acid is an exceptionally bad conductor of electricity, as has been stated by other workers—that even a current from fifty Bunsen cells would not pass through the liquid—he eventually, after several essays, succeeded in converting it into a conductor by dissolving in it a quantity of the double fluoride of potassium and hydrogen. On passing the current from twenty Bunsen cells through the now conducting medium, hydrogen immediately commenced to be evolved at the negative terminal, while fluorine was with similar rapidity evolved at the positive pole, and exhibited its tremendous activity upon everything that came near it; burning up hard crystalline silicon like tinder, setting fire to organic matter, and forming fluorides with incandescence with many other elements.

Having thus indicated the general course of these researches, it will no doubt be interesting to follow M. Moissan during the carrying out of his principal experiments.

The first series consisted in examining the action of electric induction sparks upon the gaseous fluorides of silicon, phosphorus, and arsenic. The gases were introduced into glass eudiometer tubes standing over mercury, and the spark was passed between two platinum wires connected with an induction coil actuated by a few Grenet or Bunsen cells. On introducing dry silicon tetrafluoride, SiF_4, and passing sparks for an hour, no decomposition was effected, the result being discouragingly *nil*.

Dry phosphorus trifluoride, PF_3, however, behaved quite differently, phosphorus being deposited upon the inner wall of the tube. But the fluorine liberated at once combined with the residual trifluoride to form the more stable pentafluoride, PF_5. Some time ago this pentafluoride of phosphorus was prepared by Prof. Thorpe, who also submitted it to the action of the induction spark, unfortunately without effecting any decomposition. Precisely the same result has been arrived at by M. Moissan, using a 0·04 m. spark; but on obtaining sparks 0·2 m. long, a rapid etching of the walls of the glass tube occurred, and the meniscus of mercury entirely lost its brilliancy. After an hour's duration the experiment was concluded, and the apparatus allowed to cool, when it was noticed that the volume had diminished. Moreover, the gas was found to have changed its properties, yielding a precipitate of silica in contact with water, while the residual gas consisted of the trifluoride of phosphorus. Hence $PF_5 = PF_3 + F_2$, which latter forms, with the glass, silicon tetrafluoride, and, with the mercury, fluoride of mercury. So here again the experiment was disappointing, and although fluorine was for the moment liberated, this method was certainly not suitable for the preparation of free fluorine.

Fluoride of arsenic, AsF_3, the next fluoride experimented upon, was first prepared by M. Dumas, who was severely injured in the experiment. It is a liquid which boils at 63° C., and may be easily maintained in a gaseous condition, by use of a steam jacket, and submitted to the action of the spark. It is, however, a most disagreeable substance to work with, as it produces most terrible sores when by any mischance it comes in contact with the operator's skin. On passing the sparks through it for an hour, as in case of the pentafluoride of phosphorus, the platinum wires became covered with a black incrustation of arsenic, while the walls of the tube were strongly corroded. On testing the gas, it was found to contain a large quantity of silicon tetrafluoride, mixed with a smaller quantity of free fluorine, which displaced sufficient iodine from a solution of potassium iodide to give a good coloration to several cubic centimeters of chloroform. Clearly, progress was being slowly made, though still far from the isolation of fluorine.

And now a remarkable experiment of a new type was performed. It had been noticed that, on passing an electric current through a platinum wire in an atmosphere of phosphorus trifluoride, the platinum fused, owing to the formation of a fusible phosphide of platinum; at the same time the glass of the containing vessel was etched and the mercury attacked. So the experiment was repeated on a grander scale. A quantity of spongy platinum, previously washed with hydrofluoric acid and calcined, was placed in a platinum tube 80 cm long, and of 1·5 cm. diameter. That portion of the platinum tube which required to be heated was incased in a second outer tube of glazed porcelain, so that between the two a current of nitrogen could be kept circulating, and so prevent access of furnace gases. The tube was then heated in a furnace, and pure hydrogen passed through it for some time to remove all other gases. Afterward pure nitrogen was substituted, and finally phosphorus trifluoride. After passing a short time, the current of fluoride was suddenly stopped, with a most singular result: a partial vacuum was caused, owing to absorption by the platinum.

When, however, the current of trifluoride was passed more rapidly, a small quantity of pentafluoride was formed; the fluorine liberated, when the absorption of phosphorus by the platinum occurred, having combined with the trifluoride just as in the spark experiment. But, on examining the gas which passed out of the tube under these conditions, it was found to liberate iodine from potassium iodide, attack mercury, and etch glass. In fact, it was proved that free fluorine was liberated, and mostly absorbed by the platinum, causing the diminution of pressure on stopping the current, but being more or less carried away when the current was more rapid. The fluophosphide of platinum formed was found to contain only 70 to 80 per cent. of platinum, and the formation of this substance was so rapidly effected that every experiment required a new tube.

The action of pentafluoride of phosphorus upon platinum was next tried, and with still more encouraging results. On sweeping the tube, heated in a coke blast furnace, with a rapid stream of the pentafluoride for some minutes, then moderating the rapidity, and five minutes later again increasing the speed, the issuing gas was found to blacken solid potassium iodide by liberating free iodine, inflame phosphorus, and attack crystalline silicon, glass, and mercury. It was, in fact, free fluorine drowned in excess of trifluoride of phosphorus. This was a decided advance, and the outlook was becoming considerably more hopeful.

The next experiments were made with liquid fluoride of arsenic, AsF_3, a quantity of which was placed in a platinum crucible, which served as the negative electrode. A platinum wire, dipping into the liquid in the crucible, and reaching to within five millimeters of the base, served as the positive electrode. The current from three Grenet cells was then passed through the liquid, causing a deposition of arsenic upon the interior surface of the crucible, but no gas could be perceived at the positive pole. However, on dipping the platinum wire into a solution of starch paste and potassium iodide, blue striæ were at once formed in the solution, showing the presence of a condensed gas sheath of fluorine around the platinum wire. Following up this indication, the current from twenty-five Bunsen cells arranged in series was next employed, and immediately the deposition of arsenic commenced upon the walls of the crucible, while bubbles of gas were evolved around the platinum wire. Unfortunately, the action soon ceased, owing to the bad conductivity of the liquid and the thick deposit of the arsenic. The wire, however, was strongly attacked. So attempts were next made to increase the conductivity of the fluoride by the addition of metallic fluorides, and it was soon discovered that the best results were obtained by use of the double fluoride of hydrogen and potassium, HF . KF.

It was probably this discovery which led to the grand success with which these efforts have been finally crowned, for, as has been previously mentioned, it was by the electrolysis of this double fluoride that M. Moissan eventually succeeded in preparing free fluorine.

Before leaving the experiments upon arsenic fluoride it may be mentioned that it was eventually electrolyzed in a continuous manner by use of seventy to ninety Bunsen cells, the arsenic liberated remaining in suspension in the liquid, instead of adhering to the tube, but the bubbles were rapidly seen to diminish in size in passing through the liquid, and scarcely a trace of gas escaped. Instead of permitting its isolation, the fluorine preferred to form a new fluoride, the pentafluoride of arsenic, thus once more baffling the ingenious experimenter.

But success was not now far away. The wonderful manner in which the double fluoride of potassium and hydrogen increased the conductivity of arsenic fluoride determined M. Moissan in employing it for the same purpose in an attempt to electrolyze pure anhydrous hydrofluoric acid. Faraday long ago showed that the electric current will not pass through the anhydrous acid, and Gore more recently came to the same conclusion. The current from fifty Bunsen cells was found by M. Moissan to be absolutely powerless to penetrate the acid used in these later experiments. But, on dissolving a few fragments of the double fluoride HF . KF in the acid, the current at once passed freely, and the experiment thus became possible.

The apparatus used in the first attempts with this mixture consisted of a platinum U-tube, of which each branch was closed by a paraffined cork, through which the rods of platinum forming the poles were passed. Upon each branch, just above the level of the liquid and beneath the cork, was soldered a little platinum delivery tube to lead off the gases evolved. As hydrofluoric acid boils at 19·4° C., the apparatus was immersed in a bath of methyl chloride, which boils at −23°, but which could be reduced in temperature to −50° by driving through it a current of dry air. Hence the electrolysis could be conducted without fear of the gaseous products being drowned in excess of vapor of hydrofluoric acid, and the activity of the liberated fluorine was at the same time moderated. On passing the current, a gas was at once produced at each electrode, a regular evolution of hydrogen at the negative pole, and a continuous disengagement of gas at the positive pole.

But still affairs were not satisfactory; crystalline silicon did not take fire when held in the gas coming off from the positive pole. So the apparatus was taken to pieces an hour later, in order, if possible, to find a clew to the source of failure. The paraffined cork at the negative branch was intact, but, behold the mischief, the other was carbonized to the depth of a centimeter, so the liberated fluorine had extracted hydrogen out of the cork, and passed on as hydrofluoric acid. The positive platinum rod was also much corroded. Closely fitting stoppers of fluorspar were next tried, coated with melted gutta percha, but the latter again soon melted on passing the current, and was put *hors de service*. Gum-lac and many other substances were tried, but all to no purpose, and much precious time was lost. Finally, however, the difficulty was overcome by using stoppers of fluorspar, carefully inserted in hollow cylinders of platinum carrying fine screw threads upon their outer surfaces, which engaged with corresponding threads upon the interior surfaces of the two branches of the U-tube. The platinum rods passed through the axis of each cylinder of fluorspar; the rods themselves were of square section, of two millimeters side and 12 centimeters long, and passed to 3 millimeters from the base of the U-tube; they were made of irido-platinum, containing 10 per cent. iridium, which is less attackable than pure platinum. The U-tube simply consisted of a platinum tube, bent twice at right angles, 1·5 centimeter diameter and 9·5 centimeters high, and was fitted with side tubes and immersed in methyl chloride as before.

The pure anhydrous hydrofluoric acid, which was the next necessity, was prepared in the following manner. A known volume of commercial acid was treated with sufficient potassium carbonate to neutralize about a quarter of it, and then distilled in a leaden retort over an oil bath at 120°. At this temperature the fluosilicate of potassium, formed from the hydrofluosilicic acid, contained as impurity in the commercial acid, was not decomposed, and the distillate was therefore free from silica. This distillate was then divided into two parts, and one half, saturated with pure potassium carbonate, forming neutral potassium fluoride, was then added to the other half, and transformed into HF . KF. The double fluoride was then dried at 100°, and afterward kept for some days in the vacuous receiver of an air pump, containing also strong sulphuric acid and a few sticks of fused potash. When absolutely dry it fell to powder, and was then ready for the preparation of hydrofluoric acid, which was always freshly prepared immediately before each experiment. The dry fluoride was in each case introduced into a recently ignited platinum retort, and maintained at a moderate heat for some time, so as to commence the decomposition slowly. The first portions of distillate were rejected, as they would contain the last traces of water. The plantinum receiver was then adapted and surrounded by ice and salt. On heating the retort more strongly, pure hydrofluoric acid condensed in the receiver as a limpid liquid boiling at 19·4°, very hygroscopic and fuming in the air.

While the preparation of the acid was in progress, the U-tube and electrodes were drying at 120°. From 6 to 7 grammes of the dry double fluoride were now introduced into the apparatus, the stoppers were screwed in and covered with gum lac. The whole was then fixed in the methyl chloride bath, and, until the introduction of the acid, the delivery tubes were connected with desiccators contained fused potash. A constant supply of methyl chloride at −23° was maintained in the outer cylinder, as a slight rise of temperature allowed of the volatilization of some of the acid.

About 15 to 16 grammes of the anhydrous hydrofluoric acid were then gently aspirated into the apparatus, and the current from twenty Bunsen cells allowed to pass, when immediately a regular evolution of gas occurred at each pole. At the negative pole pure hydrogen was evolved, which burnt with its characteristic flame, forming water. At the positive pole was liberated a colorless gas of penetrating and very disagreeable odor, somewhat resembling that of hypochlorous acid, and rapidly irritating the mucous membranes of the throat and eyes. It was no other than pure fluorine itself. All the trouble, all the expense, and all the disappointments were repaid. It must indeed have been a supreme moment for M. Moissan.

In order to study its action upon solids, they were placed in small glass tubes, and brought near to the orifice of the platinum delivery tube at the positive side. The test was generally repeated, holding the solids in small platinum capsules.

Sulphur, brought thus near the orifice, at once melted and inflamed; selenium behaved in like manner; as did also tellurium, with incandescence, forming fumes and becoming coated with a solid fluoride.

Phosphorus at once took fire, forming tri, penta, and oxy fluorides. Powdered arsenic and antimony combined with incandescence, the former yielding drops of AsF_3.

A fragment of iodine placed in the gas combined with production of a pale blue flame; in an atmosphere of iodine vapor fluorine itself burnt with a similar flame. Vapor of bromine lost its color and the combination was sometimes accompanied by detonation.

Cold crystalline silicon at once became incandescent, and burnt with great brilliancy, sometimes with scintillations. On closing the little tubes containing it with the thumb and opening under water, the silicon tetrafluoride formed was absorbed and decomposed with precipitation of silica. Any undecomposed silicon was found to have been fused.

Debray's adamantine boron also burnt in the gas, becoming incandescent and giving off fumes.

Fluorine has a most extreme affinity for hydrogen. They combine in the dark with explosion. In one of the experiments the electrolysis was allowed to continue several hours, so that eventually the small quantity of undecomposed acid remaining in the U-tube was insufficient to keep the two gases apart. The experimenters were consequently suddenly startled by a violent detonation. The hydrogen and fluorine had combined in the dark at the low temperature of −23°. The same detonation was afterward brought about on a smaller scale by reversing the current. On bringing the wide-mouthed delivery tube of a hydrogen generator near the orifice, the detonation at once occurred, and the hydrogen inflamed.

Metals are all attacked with more or less energy by fluorine, forming fluorides. Cold sodium and potassium were at once rendered incandescent. Calcium, magnesium, and aluminum acted similarly, in a more modified manner, becoming incandescent when slightly warmed. Powdered iron and manganese, on gently warming, burnt with bright scintillations; lead was attacked in the cold and tin at a slightly elevated temperature. Mercury, as suspected, entirely absorbed the gas, forming yellow protofluoride. Silver at a gentle heat became coated with a beautiful satin-like fluoride, soluble, unlike the chloride, in water. Gold and platinum at 300°–400° became coated with their respective fluorides, which were decomposed again at a red heat, with evolution of free flourine.

Perhaps the strongest evidence of the intense chemical activity of fluorine is exhibited in its action upon cold potassium chloride. The chlorine was at once expelled, filling the air with its disagreeable odor, and was identified by the usual chemical tests. Chlorine was also expelled from its combination with carbon in carbon tetrachloride.

All organic compounds are violently attacked by fluorine. A piece of cork at once carbonized and inflamed; alcohol, ether, benzine, and turpentine took fire immediately in contact with it.

Glass, as might have been expected, is at once corroded by fluorine. Some very delicate experiments were carried out with perfectly dried glass, with the same result.

Many other reactions, all interesting and all showing the immense energy with which the atoms of fluorine are endowed, were performed, but one especially ought to be noticed, viz., the action of fluorine upon water. It is a singular fact that, whenever oxygen is liberated in the cold, there is a great tendency to form ozone. Hence when fluorine is attempted to be collected over water, the gas collected is not fluorine, but ozonized oxygen. Water is decomposed by the fluorine forming hydrofluoric acid, while the oxygen is set free, and a considerable quantity of it is converted into the more condensed form of ozone.

On taking the apparatus to pieces after each experiment, the hydrofluoric acid remaining was found to contain a small quantity of platinum fluoride in solution, and a black mud consisting of a mixture of iridium and platinum in suspension. The negative electrode was not attacked, but the platinum rod forming the positive pole was eaten away to a point, so that one rod only served for two experiments. The average delivery of gas was about 1·5 to 2 liters per hour.

With regard to the chemical processes involved in the electrolysis, it appears probable that potassium fluoride is first decomposed into fluorine, which is evolved at the positive pole, and potassium, which decomposes hydrofluoric acid, liberating its equivalent of hydrogen at the negative pole, and reforming potassium fluoride, which may again be electrolyzed. Hence a small quantity of the double fluoride can serve for the decomposition of a comparatively large amount of hydrofluoric acid.

The double fluoride HF . KF, is very soluble in hydrofluoric acid, forming a crystallizable compound, richer in hydrofluoric acid than HF . KF, and which gives off no acid vapor at the boiling point of the anhydrous acid, 19·4°. It is this compound which one ought to seek to obtain for electrolysis, as it is very soluble in excess of acid, forming a liquid of good conductivity.

The double fluoride, HF . KF, itself was finally electrolyzed by M. Moissan. It fuses at 140° to a colorless liquid which is quite suitable for electrolysis. The experiment was performed, as before, in a platinum U tube, and, on passing the current, fluorine was again liberated at the positive pole, and at once set fire to crystalline silicon; but the platinum was strongly attacked. So the experiment was stopped in order to save the tube. On plunging a couple of platinum wires connected with the battery into a quantity of the fused double fluoride contained in a platinum crucible, gas was evolved in abundance at each pole, and on bringing the wires in contact, even in the dark, detonation occurred, owing to the combination of the evolved hydrogen and fluorine. At the same time the platinum wire from which the fluorine was evolved was almost entirely eaten away.

In concluding these remarkable researches, which have happily terminated so successfully, M. Moissan discusses very fully the question of the identity of the gas liberated at the positive pole with the element fluorine; and there can be no doubt that he has completely proved this identity, at the same time showing that fluorine occupies the place of honor as the most intensely active chemical element with which we are at present acquainted, and that it assumes its rightful position, theoretically destined for it, at the head of the group of halogens.

A. E. TUTTON.

CORROSION OF LEAD PIPES.

THE excerpt minutes of the British Institution of Civil Engineers contain the following abstract of a paper by Dr. G. Von Knorre, printed in the *Gesundheits Ingenieur*:

The author states that during the past year he has had many opportunities of examining specimens of lead pipes which have corroded in walls, owing to the action of mortar or cement, or in the soil. The behavior of lead exposed to the influence of the air, water, lime water, etc., is briefly discussed. In damp air a bright, freshly cut surface of lead becomes speedily coated with a thin scale of gray oxide, which adheres closely to the metal and prevents further oxidation. At ordinary temperature, in dry air, and in inclosed vessels specially protected from moisture by the presence of sulphuric acid or calcined chloride of calcium, lead undergoes no change; lead, however, in a fine state of subdivision, is speedily converted into protoxide. Water that has been boiled and which is free from oxygen, if air is excluded, does not dissolve lead. Shaken up with lead in the presence of air, water even in two hours takes up about $\frac{1}{10}$ per cent. of the metal. Even a corroded surface is thus attacked, and when the metal is alternately exposed to the influence of air and water the action is more rapid. All waters do not dissolve lead with equal freedom; and the presence of small quantities of carbonic acid and of certain bicarbonates retards the action, while chlorides, nitrates, and decomposing organic substances intensify it.

The experiments of Pattison Muir bearing on this subject are specially quoted, as are also the results recently obtained by Lunge and Venator. Besnou had found that lime water powerfully attacked lead, and the author, who has made careful investigation of the influence of lime water on lead, states that if air is excluded, bright lead shavings remain unaltered in the liquid, but that, on the admission of air, the metal is at once vigorously attacked. If lead is exposed to the action of lime putty, lime water, or lime mortar, air being also present, a pale yellow deposit of oxide of lead becomes visible, even in the course of a day or two, the part of the lead nearest to the surface of the putty, the lime water, or the mortar being the most freely attacked, because it is there that the air has the most ready access.

The chemical reaction is a very simple one. The hydrated oxide of lead, formed in the presence of oxygen and moisture, is dissolved in the lime water, and partially precipitated as yellow oxide, free from water (it being a well known fact that under certain conditions the yellow anhydrous oxide of lead is set free from solutions of oxide of lead in the presence of caustic alkalies or lime water as yellow or red crystals, forming a red powder). Such a precipitate of oxide of lead might be formed upon lead pipe in mortar or cement containing caustic lime in the presence of air and moisture. Two specimens of corroded lead pipe proved on analysis to contain in the corroded parts 99·05 and 99·37 per cent. of oxide of lead. The mortar in which the latter sample was embedded was extremely alkaline when tested with litmus paper, and contained a considerable quantity of caustic lime. In certain specimens of corroded pipes forwarded to the author from the Berlin water works, the part of the lead attacked was white and not yellow, and it was proved that when caustic lime is not present the hydrated oxide may be decomposed by the carbonic acid gas contained in the atmosphere, in which case a white basic carbonate of lead takes the place of the yellow oxide. Some analyses are given which show that these corroded pipes had been thus attacked, but that varying amounts of sulphuric acid, nitric acid, and chlorides were also present. The author states that these latter ingredients appear to him to play an important part in the corrosive action, for on the analogy of the old plan of manufacturing white lead with small quantities of acetic acid in dung heaps, in which process the acetic acid only acted as a carrier, the first formed acetate of lead being at once converted into carbonate of lead by the carbonic acid evolved, it can readily be seen that nitric acid would play a similar part. Indeed, both the nitrates and chlorides are known to act just as well as carriers as the acetates formerly employed in white lead making. In impure soils, rich in decaying organic matters, lead would be speedily attacked were it not for the absence of oxygen.

In a discussion on the paper it was pointed out by Mr. Oesten that, though lead may be thus readily attacked, the whole of the necessary conditions are rarely united, as out of 30,000 lead house connections in the city of Berlin he had only, after careful search, extending over a period of twelve months, found eight instances of corroded lead piping.

CARBON ELECTRODES IN THE DECOMPOSITION OF ACIDS.

MESSRS. H. Debray and Pechard recently presented a note to the Academy of Sciences of Paris on the behavior of carbon when used as positive electrode in the decomposition of acids.

When gas carbon electrodes are used in the decomsition of acids by electricity, the positive electrode becomes disaggregated more or less, quickly forming a very finely divided black powder. This fact is well known to physicists and chemists, but hitherto no explanation has been reached. Messrs. Bartoli and Papasogli, who have of late years again called the attention of savants to this fact, have devoted themselves more especially to the modifications experienced by the liquid conductors surrounding the electrodes.

Messrs. Debray and Pechard concluded that the disaggregation of the carbon was not due to a mechanical phenomenon, but that it was the result of an alteration more or less profound of the material, and that the pulverulent product derived from the carbon ought in composition to approach one of the alloys recently described by one of them. He found that the pulverulent carbon contains oxygen, water, and nitrogen as well when the electrolyte contained nitric acid. These different substances therefore combine with the carbon under the influence of the electric current, confirming the role played by electricity in forming metallic compounds.

In the liquids employed by them, the disaggregation of the carbon was not well produced with less than four Bunsen elements. The volume of gas disengaged from the positive electrode is far from being half the volume of hydrogen set free from the negative electrode, as had already been noticed. In one of their experiments the first volume was one twentieth of the other.

With hydrochloric acid, the gas set free from the positive electrode was a mixture of chlorine, carbon dioxide, and oxygen. With sulphuric acid, oxygen and carbon dioxide alone were set free. Finally, with nitric acid, an abundant disengagement of nitrous vapors containing carbon dioxide was produced. In this last experiment, if the acid is concentrated, the carbon is visibly disaggregated. A rod 4 square centimeters in section (nearly a square inch) is reduced to powder in a few hours, and the consumption is on the face turned toward the negative electrode.

Whatever acid is used, the black powder, well washed and dried *in vacuo*, deflagrates when heated above a red heat in a glass tube. Under these circumstances carbon dioxide and carbon monoxide are evolved along with nitrogen in the case of nitric acid. The quantity of water fixed by the carbon may be as much as eight per cent., and that of the oxygen ten per cent., when the electrolyte is sulphuric acid. No appreciable quantity of soluble organic matter is formed in the reactions. The same fact has been proved for solution of muriatic acid.

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